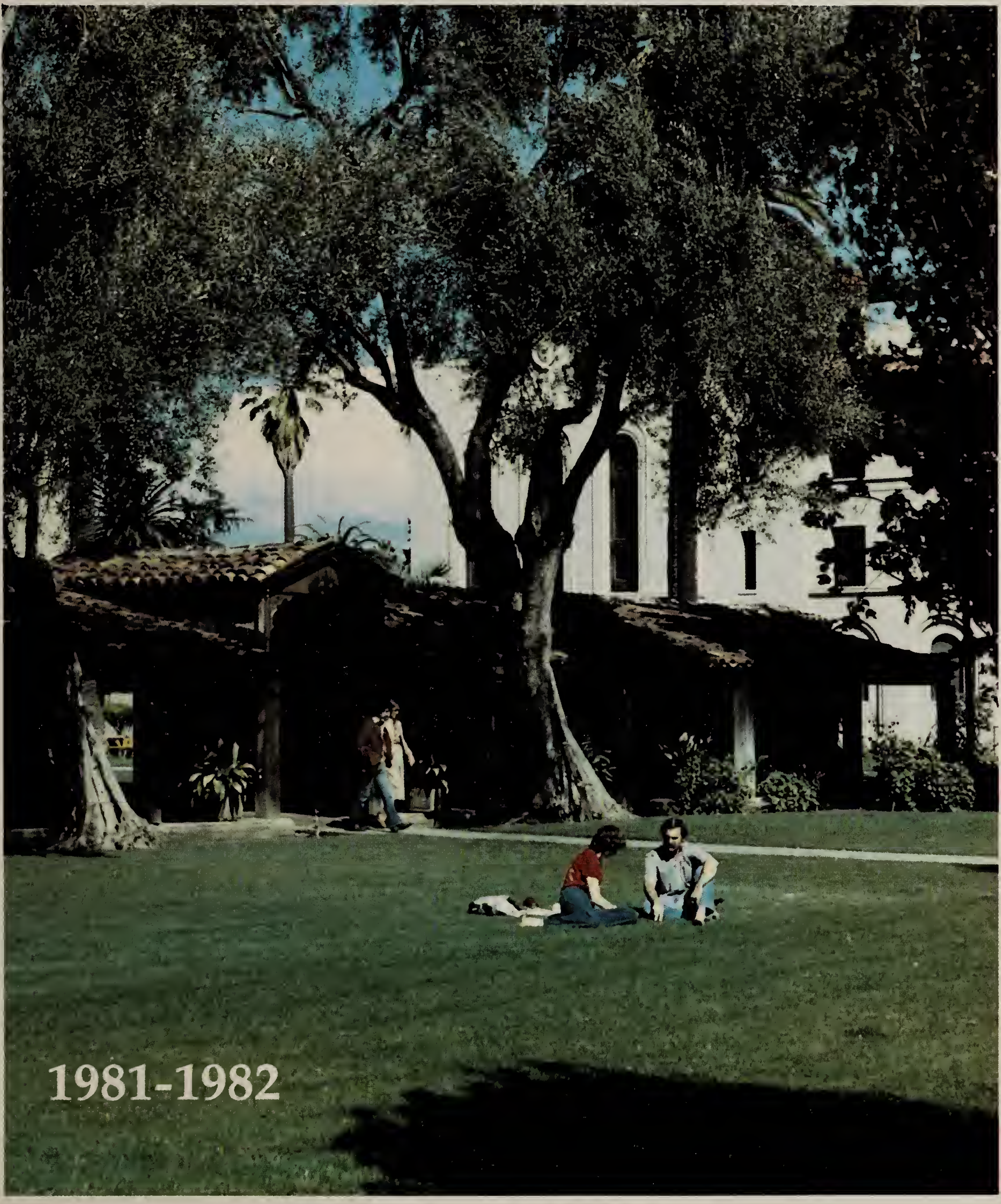
SANTA CLARA

GRADUATE SCHOOL OF ENGINEERING



1981-1982

THE UNIVERSITY OF SANTA CLARA • CALIFORNIA

UNIVERSITY OF SANTA CLARA BULLETIN

SCHOOL OF ENGINEERING GRADUATE PROGRAMS 1981-82

CONTENTS

CALENDAR 1981-82*

Fall Quarter

September 18	Friday	Registration.
September 24	Thursday	Instruction begins.
September 30	Wednesday	Last day for late registration and adding of courses.
November 19	Thursday	Last day for withdrawing from courses.
November 26-27	Thursday-Friday	Thanksgiving recess, Academic and Administrative holidays.
December 7-12	Monday-Saturday	Fall Quarter examinations.
December 15	Tuesday	Fall Quarter grades due.
December 14 January 2	Monday-Sunday	Christmas recess, Academic holidays.

Winter Quarter

December 15	Tuesday	Registration.
January 4	Monday	Instruction begins.
January 11	Monday	Last day for late registration and adding classes.
January 15	Friday	Martin Luther King's Birthday, Academic and Administrative holiday.
February 15	Monday	Presidents' Day, Academic and Administrative holiday.
March 5	Friday	Last day to withdraw from courses.
March 15-19	Monday-Friday	Winter Quarter examinations.
March 22-26	Monday-Friday	Spring recess.
March 23	Tuesday	Winter Quarter grades due.

Spring Quarter

March 22	Monday	Registration.
March 29	Monday	Instruction begins.
April 2	Friday	Last day for late registration and adding of courses.
April 9	Friday	Good Friday, Academic and Administrative holiday.
May 28	Friday	Last day to withdraw from courses.
May 31	Monday	Memorial Day, Administrative holiday.
June 7-11	Monday-Friday	Spring Quarter examinations.
June 10	Thursday	131st Commencement.
June 15	Tuesday	Spring Quarter grades due.

*All dates are inclusive dates.

Summer Session

June 18	Friday	Registration.
June 21	Monday	Instruction begins.
July 5	Monday	Independence Day. Academic and Administrative holiday.
August 2-3	Monday-Tuesday	Summer session Examinations.
August 4	Wednesday	Summer session grades due.

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HISTORICAL PERSPECTIVE

On January 12, 1777, six months after the signing of the Declaration of Independence, a cross was planted at a site in the present City of Santa Clara by a Spanish Franciscan Padre, Tomas de la Pena, to mark the founding of the eighth of California's original twenty-one missions, Santa Clara de Assis.

Three quarters of a century elapsed before the University of Santa Clara, or Santa Clara College as it was known, opened its doors as an institution of higher learning. In the intervening years, however, the Mission served as a spiritual center and school for the Indians. Besides religious instruction, the men were taught stockraising, farming, and the building trades; the girls, weaving and sewing; the boys, reading, music, and religious drama. From 1777 until Mexican government secularization, February 27, 1837, some nine thousand persons were baptized at the mission.

During the early period, the less solidly built Mission buildings of the first and second sites were destroyed by the flooding waters of the Rio Guadalupe. The third Mission church, of adobe, was completed in 1784 but was seriously damaged by earthquakes in 1812 and 1818. A fourth church, likewise of adobe, was used temporarily from 1819 to 1825. The larger fifth Mission with its quadrangle patio, also of adobe, was completed and dedicated August 12, 1825. The University's Adobe Lodge Faculty Club is all that remains of the west wing of that quadrangle.

The first site of Mission Santa Clara is marked by a California State historical landmark, located near the intersection of Kifer Road and De La Cruz Boulevard. Crosses mark the second site at De La Cruz Boulevard and Martin Street, and the third site at Campbell and Franklin Streets. The fourth Mission Church stood in the area between Kenna and Delia Walsh Administration Building on the University campus today.

During the first three decades of the nineteenth century, the old Mission enjoyed its most fruitful years. In 1827, well over fourteen hundred Indians lived within sound of the Mission's bells. In that year, some 15,000 sheep, 14,500 head of cattle, and abundant crops of wheat, corn, and beans were produced and cared for by the Indians under the Padres' guidance.

A combination of factors terminated the decades of prosperity at Santa Clara and the other California Missions. The Mexican War of Independence brought turmoil from 1810 to 1821 with resultant decrease of Franciscan personnel and donations in aid from benefactors. The new Mexican government took possession of the old Jesuit Pious Fund of the Californias that had been the main source of support for the Mission. Most of the Indians' lands, cattle, and sheep became the object of spoliation by civil administrators.

In 1827 and again in 1829, governmental decrees ordered exile for all Spaniards who refused allegiance to the new regime. Since most of the Mission Padres were from Spain, many chose banishment. Some, however, remained until 1833, when Mexican Franciscan replacements arrived from the missionary college of Zacatecas. Among them was Fray Francisco Garcia Diego y Moreno, who was to become the first bishop of the Californias. Although committed to the welfare of the Indians, the Padres' resistance to governmental encroachment upon the Indians' rights and property had little effect. Finally came full secularization of Mission properties, imposed at Mission Santa Clara in early 1837. This ended the effectiveness of the Franciscan missionary endeavor in Alta California. Within a few years, the Mission buildings and the Indian lands, cattle, and sheep fell to the possession of the civil officials and their friends.

New People, New Ways

In the early 1840's a new people and a new way of life came to Alta, California. Most of the immigrants were Anglo-Americans, attracted by the rich lands of the Santa Clara Valley. In 1848, the Treaty of Guadalupe Hidalgo ceded California to the United States. Statehood was granted in 1850.

It was in this setting that Santa Clara opened its classroom doors in May of 1851. The new Bishop of San Francisco, Joseph Sadoc Alemany, asked Jesuits Michael Accolti and John

Nobili, formerly of the Oregon Missions, to open a college at Mission Santa Clara. During its first complete academic year, 1851-52, Father Nobili and a handful of Jesuit and lay teachers offered instruction in a variety of subjects to approximately 40 students. A decision made in 1854 by the Jesuit Province of Turin, Italy, to adopt California as a permanent mission field marked a turning point in Santa Clara's history. As a consequence, the Jesuits of Turin provided the college with the faculty and support that it needed to grow. The following year Santa Clara College received a charter of incorporation from the State of California.* In 1857 the college conferred its first collegiate degree, a bachelor of arts diploma to Thomas I. Bergin. This was the first diploma granted by any institution of higher learning in the State of California. By 1858 new scientific apparatus arrived from Paris and integrated courses in science as well as in the classics and in commercial subjects were offered.

Slow and steady growth followed and distinguished graduates became prominent members of California life. However, it was not until 1912 that the Schools of Law and Engineering were founded. In that same year courses in the Humanities and the Sciences were expanded, too, and the college became the University of Santa Clara. Meeting the demands of urban growth in the Santa Clara Valley, courses in commerce and finance were also amplified in 1926, and the University's School of Business Administration began. In that same year, the old mission church was destroyed by fire. The present structure, an enlarged replica of the original, was completed in 1928.

From the 1930's through World War II, the University's enrollment was relatively stable. With the return of many war veterans, came an enlarged student body, new resources, and an expanded development. In 1947, for the first time in the University's history, enrollment broke the one-thousand mark. From the post-war period to the present, the face of the campus has been chamging and expanding. In 1961 the University announced a major change in policy and accepted women as undergraduate students for the first time in its 110-year history. Santa Clara became the first Catholic coeducational institution of higher learning in California. Thanks to the generous support of many friends, twenty-three new buildings have been added to match the growth in enrollments. Still newer facilities—the Louis B. Mayer Theatre, Leavey Activities Center, and Cowell Student Health Center—were completed in the early seventies.

Although the student body has grown rapidly in the past decade, it has been held at a relatively small size: 3,500 undergraduates and 3,500 graduate and law students. Since 1960, the number of courses taught has more than doubled and there has been a proliferation of opportunities for individual study and work/study programs.

In 1964, the University adopted an academic plan and calendar which divides the school year into three eleven-week terms and limits the number of courses a student may take to three or four in each quarter period.

As an independent, tuition and gift supported University, Santa Clara has been able to accomplish change in ways that reflect its traditional concern for the individual student.

Today, the University of Santa Clara, the first institution to offer classes in higher learning on the West Coast, continues its Mission heritage of service by assisting its students to equip themselves with the best of humanistic values and knowledge. Academic excellence in a well-balanced human being is the University's goal.

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*THE UNIVERSITY'S LEGAL NAME is: *The President and Board of Trustees of Santa Clara College* to which should be added, *A Corporation, located at Santa Clara, California.* For the information of individual, corporation, and foundation donors who wish the tax benefits of their gifts and grants, the University is classified by the Internal Revenue Service as a 501 (c) (3) (ii) tax-exempt organization and it is not classified as a private foundation under section 509 (a) of the IRS Code.

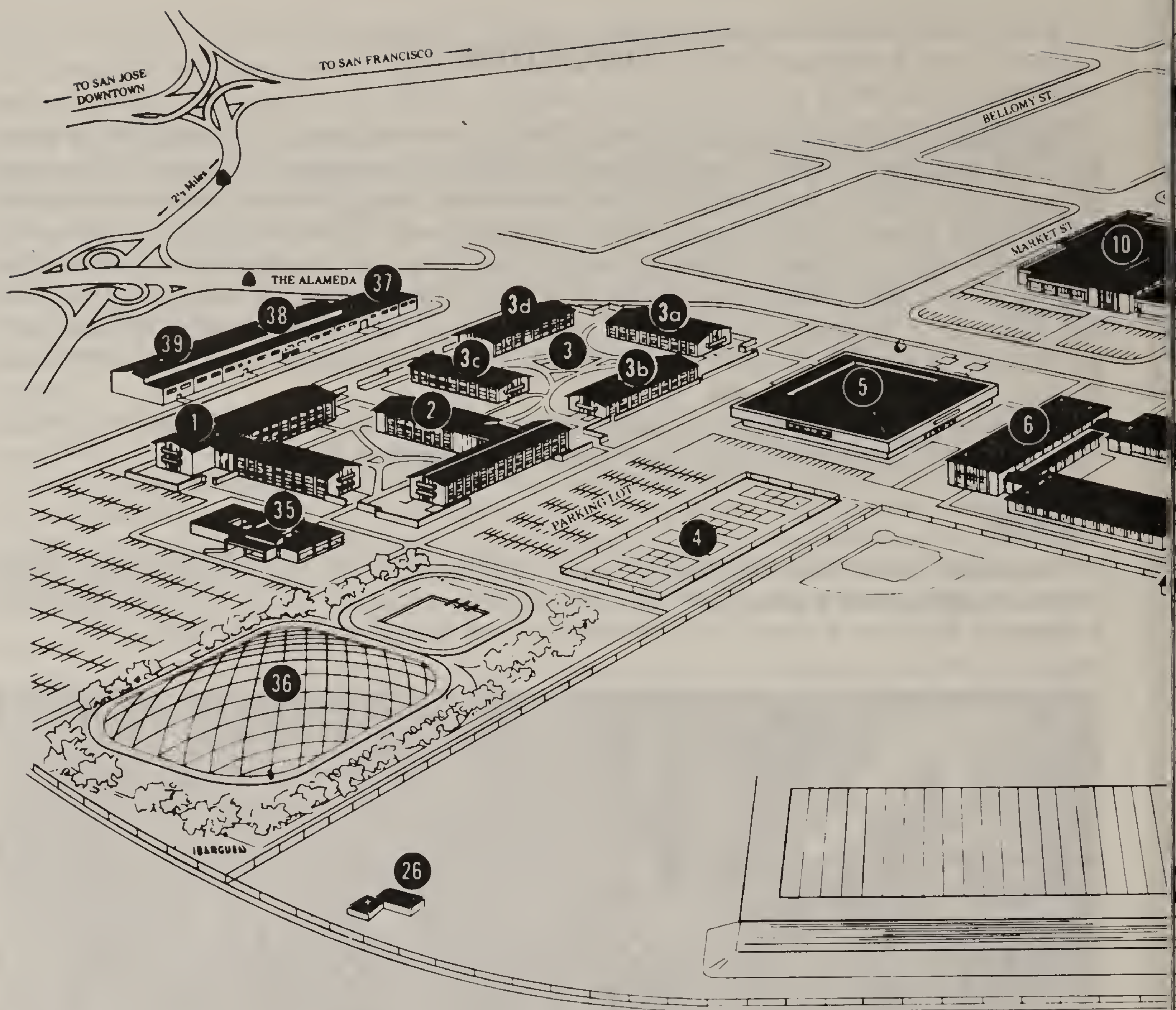
LOCATION

The University of Santa Clara is 46 miles from San Francisco near the southern tip of the Bay in an area that is rich in opportunities for learning. The campus is situated in the midst of one of the nation's great concentrations of high-technology industry and of professional and scientific activity. Many nearby firms and social agencies are world leaders in the search for solutions to man's most critical problems. The cultural and entertainment centers of San Francisco, Berkeley, Oakland and Marin County are within one hour's travel by bus, train or car. In the opposite direction, about thirty minutes away, are the beaches of Santa Cruz on the Pacific Ocean, and less than two-hours' drive from the campus is world-famous Monterey Peninsula and Carmel.

The University is accessible by major airlines via San Jose Municipal Airport just three miles away and via San Francisco and Oakland International Airports.

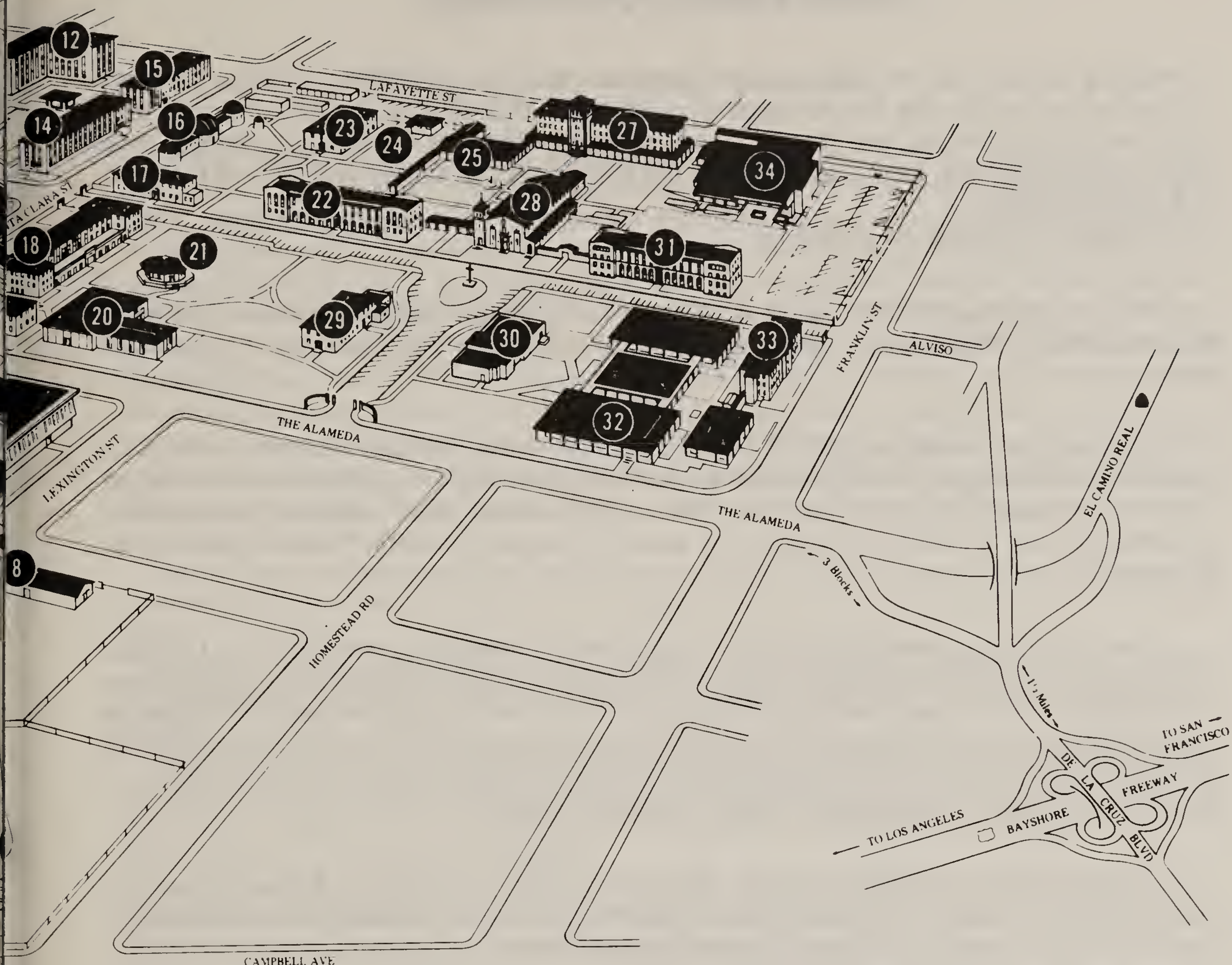
Climate

Santa Clara has a moderate Mediterranean climate. Over a period of 67 years the average maximum temperature was 71.4° and the average minimum 41.6°. The sun shines an average of 293 days a year and the average annual rainfall is about 15 inches.



UNIVERSITY OF SANTA CLARA C

- ❶ Sanfilippo Residence Hall
- ❷ Campisi Residence Hall
- ❸ Graham Residence Center
  - Ⓐ Strub Hall
  - Ⓑ Swig Hall
  - Ⓒ Hancock Hall
  - Ⓓ O'Neill Hall
- ❹ Campus Tennis Courts
- ❺ Michel Orradre Library
- ❻ Sullivan Engineering Center
- ❼ Bannan Classroom Building
- ❽ Field House
- ❾ Buck Shaw Stadium
- ❿ Benson Memorial Center
- ⓫ Benjamin Swig Residence H
- ⓬ Dunne Residence Hall
- ⓭ John Kennedy Mall
- ⓮ McLaughlin Residence Hall
- ⓯ Walsh Residence Hall
- ⓰ Ricard Memorial Observator
- ⓱ Donohoe Alumni House
- ⓲ Kenna Hall - School of Busi
- ⓳ Bergin Hall - School of Law



PUS

20 Heafey Law Library	30 De Saisset Art Gallery & Museum
21 Staff Lounge	31 O'Connor Hall
22 St. Joseph's Hall	32 Daly Science Center
23 Varsi Hall, Admissions/Development	33 Alumni Science Hall
24 Restrooms	34 Mayer Theatre
25 Adobe Lodge - Faculty Club	35 Cowell Student Health Center
26 Univ. Day Care Center	36 Leavey Activities Center
27 Nobili Hall — Jesuit Residence	37 Fine Arts Building
28 Mission Santa Clara	38 Dance Building
29 Walsh Administration Building	39 Music Building

A STATEMENT OF PURPOSE

Inspired by the love of God through human service and the desire to serve through education, begun by the Franciscans who founded Mission Santa Clara in 1777 and continued by the Jesuits who opened the College in 1851, the University of Santa Clara declares its purpose to be the education of the human person in the context of its Catholic and Jesuit tradition.

The University is thus dedicated to:

- the continuing development of a community of highly qualified scholars, teachers, students and administrators committed to an uncompromising standard of academic excellence;

- providing an education that, in its emphasis on undergraduate education and in its pursuit of selected high quality graduate and professional programs consonant with such an education, stresses the development of moral as well as intellectual values, an education of the whole person, an education constantly seeking to answer not only "what is" but "what should be";

- the continuing development of an academic community informed by Catholic principles, a community offering its members the opportunity for worship and for deepening their religious commitment, yet a community that is enriched by men and women of diverse religious and philosophical as well as social and racial backgrounds, a community opposed to narrow indoctrination or proselytizing of any kind, a community wherein freedom of inquiry and freedom of expression enjoy the highest priority;

- offering an integrated curriculum designed not only to provide the scientific and humanistic knowledge necessary to enable students to develop fully as persons, but also to demonstrate the unity of all forms of knowledge and to enable students to assume roles of leadership in the modern world;

- encouragement of teaching excellence and of the scholarly research that promotes such excellence, of close student-teacher relationships, of experimental and innovative courses and teaching methods—courses and methods that stimulate not only the acquisition of knowledge but also the creative use of knowledge;

- the continuing development of an academic community in which students, teachers and administrators dedicated to academic freedom and united in the search for truth are actively involved in formulating and implementing the University's policies.

Board of Trustees
University of Santa Clara
January 22, 1975

THE SCHOOL OF ENGINEERING

Robert J. Parden, Ph.D., *Dean*

To the goals of fundamental knowledge—an inquiring mind, good habits of self-discipline—the professional school adds the requirement of preparation to make a specific social contribution. Engineering knowledge was once passed from generation to generation in the familiar pattern of the apprenticeship. With the increasingly complex applications of science which provided the groundwork for the Industrial Revolution, those who were charged with applying science to the needs of the society in which they lived—engineers—turned to the universities for increased formal preparation in science and mathematics. To accelerate the rate at which knowledge of contemporary engineering applications could be learned above that of the apprenticeship, schools of engineering developed—extending the curriculum beyond science and mathematics to include the methodology of engineering applications. Not only were the traditional goals of the University embraced, but to them were added specific professional needs—needs not only of the individual, but of the profession he or she represents.

The function of engineering is to bridge science and society; to modify nature to meet the needs of society within the restrictions dictated by social, political and economic considerations.

In order to act as the bridge between science and society, the engineer must be both knowledgeable in science and sensitive to the means which can be used to satisfy social needs.

The rapid expansion of knowledge and complexity in all areas of science and engineering suggests the need to both broaden the educational program and to increase specialization. Both goals cannot be accomplished in four years of undergraduate study; hence, the development of the graduate program.

The engineering activity requires all types of people with different interests, preparations, and abilities. Regardless of the field of engineering, there is a pattern of assignments describing the kinds of jobs in which engineers engage. These include:

Technical Management in which the engineer directs a team of engineers—technicians, mechanics, and other skilled artisans.

Consulting in which the engineer alone, or as part of a firm, offers services to a client needing professional counsel.

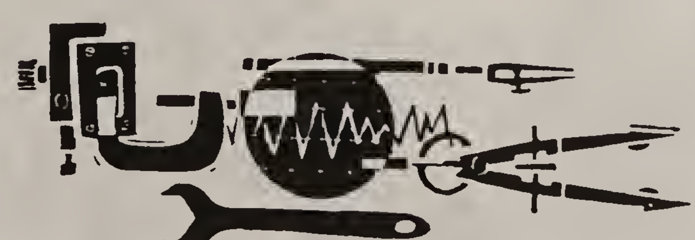
Design in which the engineer plans structures or systems, using knowledge of scientific principles and the properties of materials.

Research and Development in which the engineer seeks additional knowledge about basic, physical phenomena and develops this knowledge into a product or service. In this assignment the engineer works closely with the scientist, and often their division of labor is difficult to identify.

Construction and Production in which the engineer translates the design engineer's drawings and specifications into structures, machines, or systems.

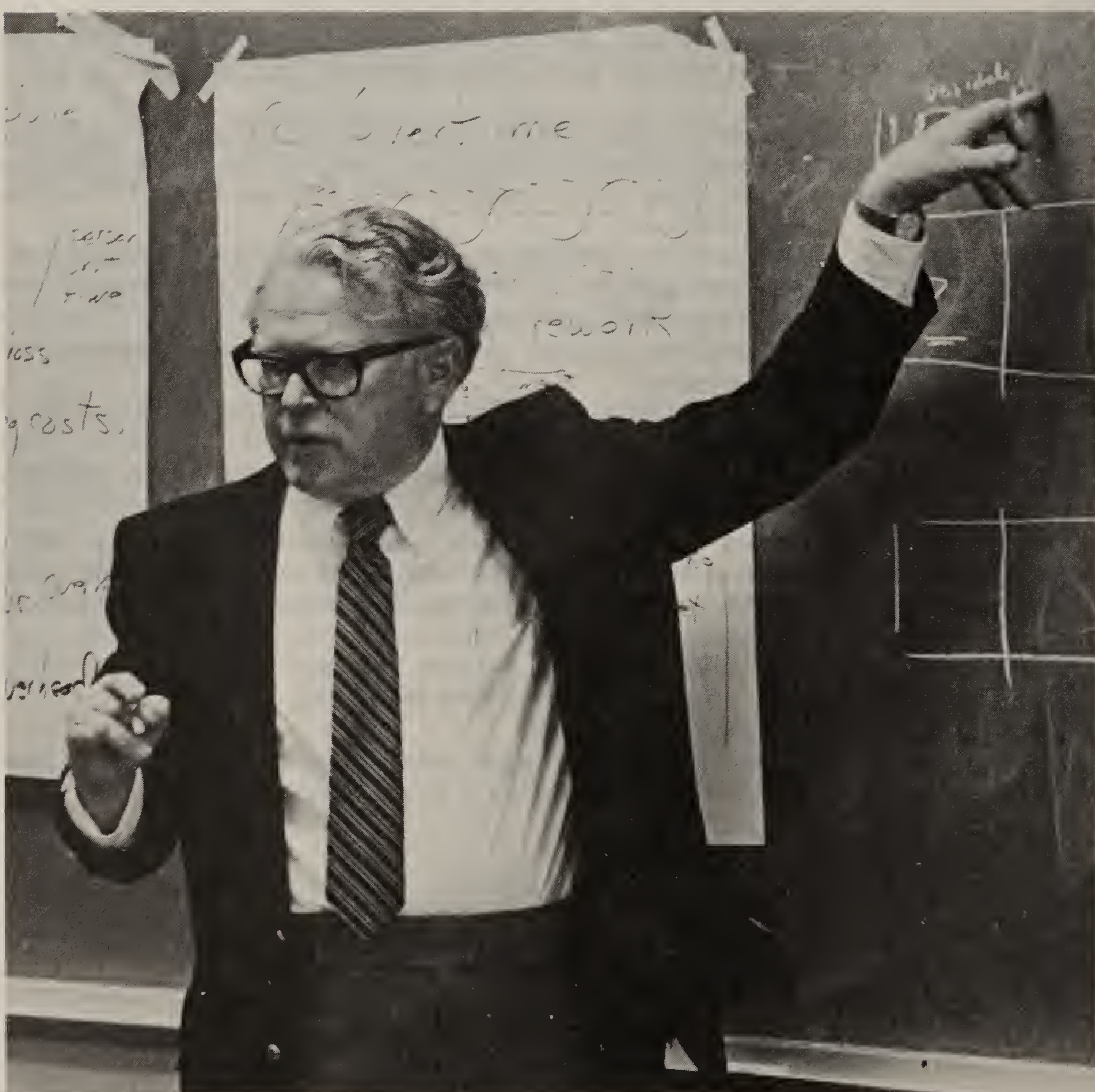
Teaching in engineering schools and colleges.

These are general assignments. Engineers also undertake assignments which require background and experience, such as administration, management, and sales.



ENGINEERING AT SANTA CLARA

The undergraduate programs leading to the Bachelor of Science in Engineering and in Civil, Electrical, and Mechanical Engineering were first offered at the University of Santa Clara in 1912 and they were accredited by The Engineers Council for Professional Development in 1937. Since that time, the Bachelor of Science in Engineering, Bachelor of Science in Computer Science (in the School of Engineering), the Master of Science in Electrical Engineering and Mechanical Engineering, Computer Science, Engineering Management, Engineering Mechanics, Applied Mathematics, the Master of Science in Engineering, the Engineer's degree in Electrical and Mechanical, and the Doctor of Philosophy in Electrical Engineering programs have been added.



FACILITIES FOR ENGINEERING

The School of Engineering's laboratories are contained in three buildings in the Sullivan Engineering Center built in 1960.

Civil Engineering and Engineering Mechanics Laboratories

Materials Engineering Laboratories: Facilities in these laboratories include those of the physical testing lab, the concrete lab, and the experimental stress lab. Construction materials may be tested in tension, compression, torsion, flexure, impact and fatigue, and for hardness. Experimental stress equipment includes polariscopes, loading frames, and a variety of types of strain gages. Concrete may be designed, mixed, cast, cured, and tested in the laboratory.

Design Laboratory: The design laboratory, in addition to being equipped with drafting boards and stools, maintains other aids for civil engineering. These include unusual equipment which is used only occasionally, as well as a library of standard and sample plans, and manufacturers' catalogs. The department also maintains a design library, including handbooks and reference works.

Geotechnical Laboratories: Both soil and geological laboratories are equipped for demonstration work and for hands-on student participation. Extensive mineral and rock samples are available as are topographic, geologic, and soils maps, reports and airphotos. Field testing and sampling equipment is available and the standard identification, classification, compaction, and various strength tests can be performed.

Electrical Engineering and Computer Science Laboratories

Laboratories and facilities are available for research and instruction in electrical machinery, electric controls and servomechanisms, computing, electrical measurements, electronics, and communications.

The Computing Laboratory includes a general purpose minicomputer, several microprocessor development systems, terminals, and recording and other accessory equipment, coupled with a range of software support for these systems. These facilities are used primarily for student and faculty research, including development of new computing devices and techniques.

In addition to this computer facility within the Department, two of the University's general purpose digital computers are located nearby. Computing time is available for regularly scheduled instructional classes and for the research activities of graduate students and the Engineering faculty.

The Electronics and Communications Laboratories provide modern facilities in electronics, radio communication, and microwaves. These laboratories are equipped with signal generators, oscillators, precision bridges, cathode-ray oscilloscopes, Q-meters, wave analyzers, spectrum analyzers and other precision measuring equipment.

The Control Systems Laboratory is well-equipped with modern instruments for experimental studies of individual control-system components and of complete systems. In addition to the usual electronic test equipment, there is equipment for construction and test of many types of servos, modern oscillographic recorders, and numerous analog and digital components. From time to time additional special-purpose test equipment is constructed to facilitate studies of adaptive control systems, digital control systems, and carrier control systems, among others. This equipment is frequently supplemented by the use of analog and digital computers located in adjacent laboratories.

The Electromechanical Energy Conversion Laboratory is equipped with Westinghouse generalized machines, transformers, and associated equipment.

Computer Science and Digital Systems Laboratories

The Computer Science and Digital Systems program is supported by the facilities of the University's Academic Computing Center and the Digital Systems Laboratory.

The *Academic Computing Center* minicomputer facility employs both Digital equipment PDP-11/34 and Hewlett-Packard HP-2100 computers. The HP-2100 computer is normally run in batch mode under HP's DOS-111 disk operating system. Writable control storage facilities are available on this system for use in conjunction with microprogramming projects. The PDP-11/34 supports 12 terminals under the RSTS/E operating system. Languages include PASCAL. ALGOL, FORTRAN, and BASIC.

The Academic Computing Center Mainframe facility operates a Digital Equipment Corporation DECSYSTEM 2060, with 30 terminals, under the TOPS-20 operating system. Available languages include PASCAL, USP, SNOBOL 4, SIMULA and FORTRAN.

The *Digital Systems Laboratory* provides complete facilities for experiments and projects ranging in complexity from a few digital integrated circuits and other electronic components to complete computer systems.

The EECS department operates a microprocessor laboratory consisting of INTEL SDK-85 microprocessor boards networked to an IMSAI microcomputer with facilities for cross assembly, file storage, and listing.

Mechanical Engineering Laboratories

The Mechanical Engineering Laboratories include bench laboratories and a high-bay facility for experimentation in free-fall systems, fluid mechanics, thermodynamics, heat and mass transfer, propulsion, combustion, power generation, air conditioning, and exhaust emissions.

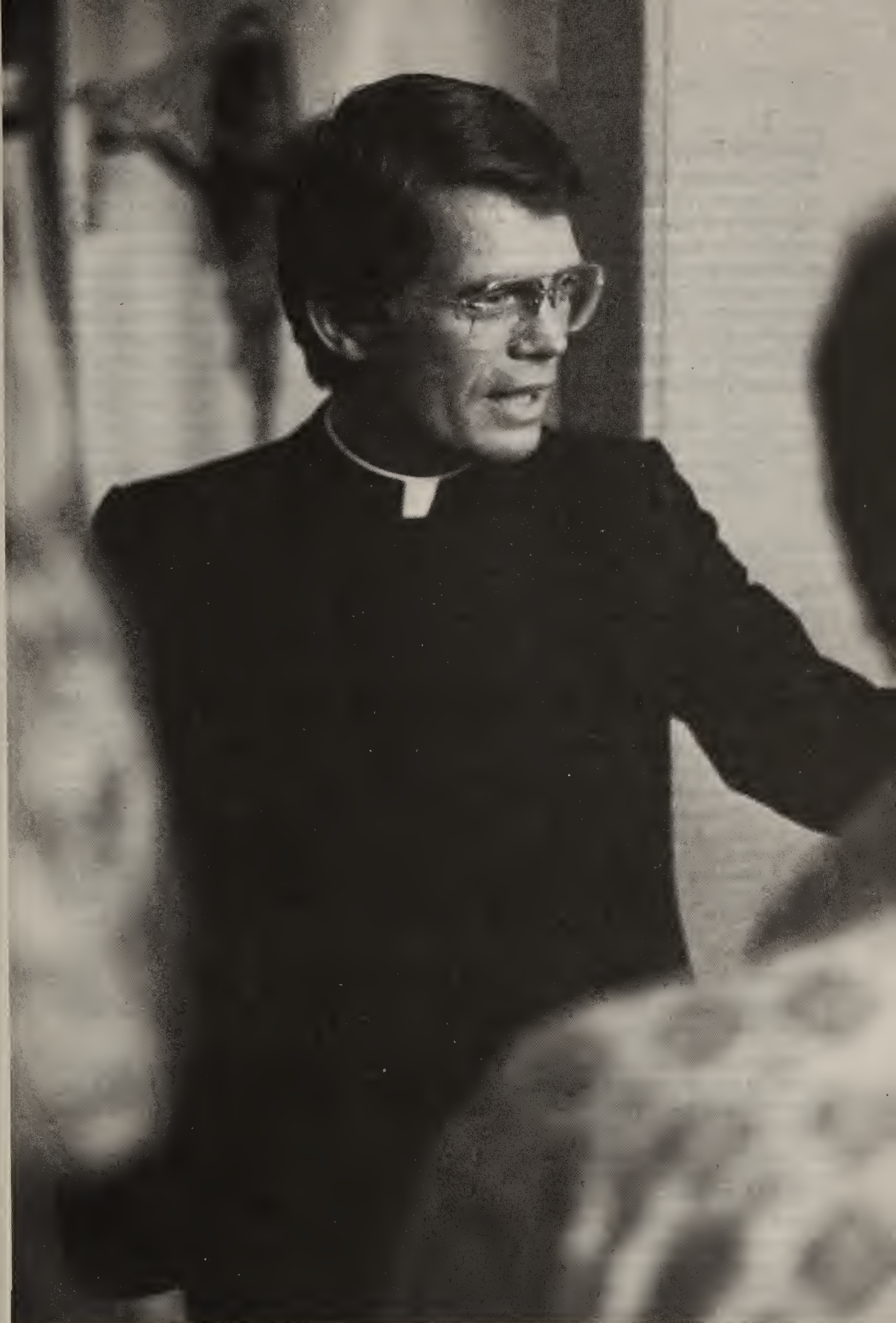
A variety of internal combustion engines installed on dynamometer stands can be used for studies in diesel and spark-ignited engine performance. An axial-flow fan with adjustable blades attached to a wind tunnel permits a variety of experiments to be performed in aerodynamics and turbomachinery.

The fluid dynamics area contains equipment to illustrate the principles of fluid flow and to familiarize the student with basic elements of hydraulic machinery and their associated instrumentation. Each device may be supplied directly from a pump or from a constant level standpipe with a 25-foot head.

Included in the Mechanical Engineering Laboratories is the equipment associated with electromechanical energy conversion. A variety of direct and alternating-current machines, transformers, and associated equipment is available.

A unique approach is made in utilization of a complete metal processing facility. The first course in this area is taught by an engineer in order that the students become familiar with machine-tool processes from an engineering design point of view. The student further utilizes the shop facility during thesis activities. The facility is also utilized for construction and maintenance of experimental apparatus.

Recent additions to the laboratory facilities are a calorimeter for determining human metabolic behavior, high vacuum fuel ignition apparatus, and electronic instrumentation for detailed study of combustion exhaust pollutants.


William J. Rewak, S.J., President

MASTER OF SCIENCE PROGRAM

Entrance Requirements

Application for admission to graduate standing should be made to the Dean of the School of Engineering on the form available from that office. Official transcript of record covering all college and university work completed to date, together with official evidence of degrees conferred, must be received prior to admission as a graduate student. Two separate, original and official records must be presented from each institution previously attended. In order to ensure processing of applications, they must be received, together with transcripts of previous work, at least four weeks before registration for the initial enrollment. Material received later may prevent or delay registration and subject the student to the late registration fee.

Students will be admitted if they:

1. Received a Bachelor's degree in Engineering from an ECPD accredited four-year program substantially equivalent to that of Santa Clara, and plan to undertake a graduate program in the same field.

   or

   Received a Bachelor's degree in Computer Science, Engineering, Mathematics, or one of the Physical Sciences from an accredited four-year program substantially equivalent to that of Santa Clara and plan to undertake a Master of Science program in Computer Science. The student must have completed mathematics courses through the calculus, and differential equations, and a college-level physics sequence using the calculus.
2. Accomplished a scholastic average of at least 2.75 (based on a 4.0 maximum) in the technical work of the last two undergraduate years.
3. Students from countries other than the United States will be considered for admission only on a full time basis (a minimum of 9 units per quarter). A minimum enrollment of ten quarter units is necessary to retain a student visa. TOEFL, GRE Aptitude, and GRE Achievement in Engineering scores are required before applications are processed.

The School reserves the right to deny admission if the previous program has not been of such character as to furnish an adequate foundation for advanced academic study.

Program of Studies

All students must file a Program of Studies during their first term of enrollment at the University of Santa Clara.

The Program of Studies is a plan of study which, when satisfactorily completed, will merit receipt of the appropriate degree. It is initiated by the student on the appropriate form, approved by the faculty member assigned by the major department, and filed in the office of the Dean of the School of Engineering.

Degree Candidacy

Each student seeking a degree must file for degree candidacy before he or she has completed 35 quarter units. At least ten quarter units must be completed at Santa Clara after degree candidacy is received. Since a 3.0 grade point average is required in work taken in graduate standing to earn the Master's degree, candidacy will not be granted until that achievement level is reached.

Master's Thesis

All students who seek the Master's degree and are enrolled on a full-time basis must submit a Master's Thesis unless specifically exempt. Students who wish to substitute course work must receive written permission from the major department to make the substitution.

Master's Degree Requirements

The Master's degree will be granted to degree candidates who complete a program of studies which has been approved by the major department. It must include no less than 45 quarter-hours of which nine may be earned by completing a thesis. In addition, a quality level of 3.0 (a B average) must be earned in course work taken at Santa Clara while enrolled in the Graduate Degree Program. Residence requirements of the University will be met by completing 36 quarter-hours of the graduate program at Santa Clara. All units applied toward the degree, including those transferred from other institutions, must be within a six-year period.

All degree candidates must file a degree application with the Dean of the School of Engineering at least three months before the day on which the degree is to be granted. A degree application form may be obtained from the same office.

Incompletes

A student's work may be reported incomplete if, due to illness or other serious circumstance, some essential portion of the work in the course remains unfinished after the final examination, or because the thesis is not completed. An incomplete (1) becomes a Failure (F) unless the unfinished work is completed to the satisfaction of the instructor and proper notice filed with the Registrar within four weeks from the beginning of the next scheduled term, not including the summer session, whether or not the student is registered during that term. Make-up work must be in the hands of the concerned faculty member no later than the end of the third week so that the professor can meet the four-week submission deadline.

Department Requirements

Engineering Mechanics

The master's degree in Engineering Mechanics may be earned by part-time students in a program of Early-Bird courses. A minimum of three years is required. Students whose work load is too heavy to accomplish the program in the minimum time may take longer. The following four-unit courses will be required of all candidates:

CE 209	Thin Plates and Shell Structures
CE 211	Advanced Strength of Materials
CE 214	Theory of Elasticity
CE 216	Theory of Plasticity
CE 218	Dynamics of Structures
CE 221	Stability of Structures
CE 222	Statically Indeterminate Structures

In addition the candidates shall earn credit in Applied Mathematics 130 and 131 and four other units of Applied Mathematics. The balance of the program shall be optional courses approved by the advisor.

Computer Science

A program of studies for the MSCS degree must contain a minimum of 25 Electrical Engineering and Computer Science units and must include:

1. One of the following core sequences in Digital Systems and Computer Science; two courses selected from a second sequence; one course selected from a third sequence, and three computer science courses selected from EECS 306-329, 401-403, 411-426.

   (a) hardware core: EECS 306, 307, 308
   (b) software core: EECS 310, 312, 313
   (c) theory core: EECS 420, 421, 422, 424

NOTE: EECS 301, 302, 305 and 311 are fundamental courses. The subjects covered are essential to successful pursuit of the MSCS degree, and these courses are prerequisites for required courses. However, the units earned in these courses may not be included in the 45 required for the MSCS degree. Thus, students without programming competency in a block-structured higher-level language (e.g., ALGOL, PASCAL, PL/1) must take EECS 301 or EECS 410 prior to taking EECS 310. Students without programming competency in an assembler language must take EECS 311 prior to taking EECS 307 or 312. Students without competency in logic design must take EECS 302 and 305 prior to taking EECS 306.

2. Two of the following course sequences in Applied Mathematics:

   (a) AM 110 and 111: Introduction to Probability I and II.
   (b) AM 120 and 121: Numerical Analysis I and II.
   (c) AM 140 and 141: Modern Algebra I and II.
   (d) AM 145 and 146: Linear Algebra I and II.
   (e) AM 270 and 271: Optimization Techniques I and II.
   (f) AM 180 and 181: Combinational Mathematics I and II.
   (g) AM 240 and 241: Linear Programming I and II.
   (h) AM 246 and 247: Graph Theory I and II.

3. Students who do not have an undergraduate degree in electrical engineering must also take: EECS 210, 230, and 250, or their equivalent.

Adjustment of these requirements and any alterations in the program of studies must be through the academic advisor.

DEGREE CANDIDACY: Students not admitted to degree candidacy at initial enrollment must complete a minimum of 15 units to become eligible for degree candidacy.

Electrical Engineering

PROGRAM OF STUDIES: Students must file a program of studies during their first term of enrollment at Santa Clara.

The program of studies must contain a minimum of 25 Electrical Engineering and Computer Science units and must include:

(1) One graduate course in Electromagnetic Fields (EECS 201)
(2) Two graduate courses in Modern Networks (EECS 211 and EECS 212 or EECS 213 or EECS 214)
(3) One graduate course in Control Systems (EECS 236)
(4) One graduate course in Electronics (excluding EECS 250)
(5) Demonstrated competence in logic design and programming (e.g., EECS 305 and EECS 301 or 410, or acceptance by the advisor of previous studies.)
(6) Four applied mathematics courses, including the AM 145-146 sequence.
(7) Such additional courses in the student's area of emphasis and in other areas as shall be developed with the advisor, and approved as a part of the student's total program (minimum of 45 hours).

These requirements may be adjusted by the student advisor on the basis of the student's previous graduate work. (Before completion of 10 units, and preferably as early as possible.) Alterations in the approved program, not relating to the above Departmental requirements, may be requested at any time by petition initiated by the student through the advisor. (Petititon forms available in EECS office.)

DEGREE CANDIDACY: Students who are not admitted to degree candidacy at the time they enroll must apply for candidacy after they have completed at least 15 units at Santa Clara, with a grade point average of 3.0.

Mechanical Engineering

A program of studies to meet the interest of the individual should be developed with a member of the Department. Candidates for the Master's degree must submit their proposed program for departmental approval upon filing for candidacy status. The program must contain at least six units in advanced mathematics and one course in advanced physical or life sciences. A maximum of 5 units may be taken in the Graduate School of Business upon departmental approval.

MASTER OF SCIENCE IN ENGINEERING

This program was initiated to accommodate those who wish to seek goals which do not fall within the patterns of the designated degree programs. A program which combines engineering, mathematics, and the physical and life sciences might be a desired plan. The program must be made up of courses in engineering, mathematics, or science, approved by an advisor, and filed at the time degree candidacy is sought.

MASTER OF SCIENCE IN APPLIED MATHEMATICS

The Applied Mathematics program is open to those students who have earned a B.S. degree in Engineering, Science, or Mathematics. A minimum of 45 quarter-hours of mathematics must have been completed. The undergraduate preparation must include courses through the calculus (16 quarter-units), differential equations (4 quarter-units), advanced calculus (4 quarter-units), algebra—modern algebra, linear algebra, or matrix theory— (4 quarter-units), complex variables (4 quarter-units). The remaining hours may be satisfied by courses in applied mathematics or analysis.

The courses for the Master's degree must include no less than 30 quarter-hours in Applied Mathematics at which a minimum of 12 quarter-hours must be in 200-level courses. The balance of the program may be in related areas in engineering or physics.

MASTER OF SCIENCE IN ENGINEERING MANAGEMENT

At some time in the career of every professional, responsibility for one's own work expands to include responsibility for the work of others. The Master's degree in Engineering focuses on just one aspect of how we do work—the management of technical activities through which the manager integrates physical and human resources he or she sets objectives, organizes, motivates, communicates, measures performance, and develops people. The Engineering Management course work encompasses these activities, and how they interface with the other activities in the organizations in which the engineering activities take place.

Unlike more general programs in management or in business administration, this program accommodates the unique formal education of engineer, and is designed for those who expect to continue in technical activities for the immediate future.

Admissions

Admission to the Engineering Management Program is open only to those who hold an undergraduate degree or graduate degree in engineering. The undergraduate program must be a four year Engineering program substantially equivalent to Santa Clara's. In addition, students must have two years of full time work experience after receiving their bachelor's degree. No full time students are enrolled in this program. It is possible to commence the technical course stem without meeting this experience requirement.

Engineering Management Degree Requirement

Forty-five quarter units are required for the Master's Degree at Santa Clara. For the Engineering Management Degree, 20 of these units must be in a sequence in Civil, Electrical, or Mechanical Engineering, Computer Science, Engineering Mechanics or Applied Mathematics. A minimum of twenty units must be undertaken in the Engineering Management sequence. Management type courses undertaken in other engineering or business departments must be counted in the remaining, non-designated, five quarter units. Note that the number of Engineering Management courses accepted for other degrees in the graduate engineering program is restricted to six units in Civil, Computer Science, Electrical, and Mechanical Engineering, and ten units in the Master of Science in Engineering Degree.

The program of studies for Engineering Management Degree candidates can be submitted either to the Engineering Management Program coordinator, or to the department in which the technical stem will be pursued. This should be submitted during the first term of enrollment to insure that the overall program is acceptable.

The following courses are not applicable to an Engineering Management Degree Program:

52.301 Introduction to Programming
52.302 Introduction to Digital Systems

Graduate Seminars, such as EECS 200, offered by departments other than the department providing the candidate's technical stem.

In addition to the overall 3.0 gradepoint graduation requirement, the Engineering Management Degree candidates must earn a 3.0 average in those courses applied to their technical stem, and a 3.0 gradepoint average in their engineering management course stem.

THE ENGINEER'S DEGREE PROGRAM

The program leading to the degree of Engineer is particularly designed for the continuing education of the practicing engineer. It is offered in Electrical and Mechanical Engineering, and Engineering Mechanics. The degree is granted upon completion of an approved academic program and a record of acceptable technical achievement in the candidate's field of engineering. The academic program consists of a minimum of 45 quarter-units beyond the Master's degree. Courses are selected to advance the engineer's competence in specific areas relating to his or her professional work. Evidence of technical achievement must include a paper authored principally by the candidate and of such quality as to be published in a recognized engineering journal. All papers must be submitted to appropriate journals and accepted for publication prior to the granting of the degree. In certain cases the Department may accept publication in the proceedings of an appropriate conference.

Admission to the program will in general be granted only to those students who demonstrate superior ability in meeting the requirements for their Master's degree. Normally, the Master's degree would be earned in the same field as that in which the Engineer's degree is sought.

A program of studies for the Engineer's degree should be developed with the assistance of an advisor and submitted during the first term of enrollment. An application for degree candidacy must be submitted prior to the completion of ten quarter-units of course work.

In the field of Electrical Engineering, courses which that Department consider to be at the introductory Master of Science level (such as EECS 201, 210, 211, 212, 230, 231, 236, 241, 250, 251, 301, 302, 305, 341, 342, 410, AM 110, 111, 120, 121, 130, 131, 135, 136, 140, 145, 146) are not generally acceptable in an Engineer's Degree program of studies. With the approval of the advisor the student may include up to three of these courses in an Engineer's Degree program. The Department also requires that at least 15 units of the program of studies be in topics other than the student's major field of concentration. Candidates admitted to the program in Electrical Engineering who have MS degrees other than in Electrical Engineering must include in their graduate program (MS and EE combined) a total of at least 45 units of graduate level Electrical Engineering course work, exclusive of computer software courses.

Students should consult the departments for other degree requirements.

THE DOCTOR OF PHILOSOPHY PROGRAM

The degree of Doctor of Philosophy is conferred by the School of Engineering primarily in recognition of competence in the subject field and the ability to investigate engineering problems independently. The work for the degree consists of engineering research and the preparation of a thesis describing it, and a program of advanced studies in engineering, mathematics, and related physical sciences. The student's work is directed by the department, subject to the general supervision of the School of Engineering. Currently, Electrical Engineering and Computer Science is the only department granting the degree.

All applicants for the doctoral program are required to take the Advanced Engineering Test of the Graduate Record Examination administered by the Educational Testing Service, 4640 Hollywood Boulevard, Los Angeles, California 90027, or 20 Nassau Street, Princeton, New Jersey 08540. The Testing Service must be requested to forward the results to the Dean, School of Engineering. An academic achievement of the Master's level, or its equivalent, is usually required of all applicants. Students who are in an advanced stage of the M.S. program may petition to the Department of Electrical Engineering and Computer Science for the right to take the test prior to the completion of the M.S. degree requirements. Students who have earned the Master's degree from the University of Santa Clara must file a new application to continue work toward the Doctor's degree.

All applicants for doctoral degree programs who have submitted an Application for Admission as described below, and have been admitted by the School of Engineering to advanced standing, and have been assigned an advisor, shall present themselves for preliminary examinations by their major department at such times as shall be set by the departments. These examinations shall be written and/or oral and shall include fundamentals of mathematics and the physical sciences, as well as engineering subjects.

Only those applicants who have shown sufficient background and promise in the preliminary examinations shall be accepted as doctoral candidates. The preliminary examinations may be repeated only once, and then only at the discretion of the major department and after one year.

The applicant should:

1. Submit an Application for Admission to the Engineering School.
2. Submit a list of three references who can attest to the potential of the candidate.
3. Submit a 500-word biography indicating the applicant's academic, research, and professional goals.
4. Submit, if requested, copies of theses, papers, or reports written by the applicant.

5. Submit copies of transcripts of academic records at all universities attended. Please request the Registrar of each university to forward the transcript directly to the Dean, School of Engineering.

Registration

Students are required to file a program of studies with the Department during the first quarter of attendance. This program must be approved by the Graduate Programs Committee. The student's advisor must approve the portion of the program to be undertaken each quarter, whether it is research, course work, or independent reading. An amended program must be filed to record any changes from the original program. Changes must be approved by the Graduate Programs Committee.

A student will not receive credit for a course unless properly registered. Units assigned for research shall be determined by the instructor. The instructor may reduce the number of research units for any term in which the anticipated research progress is not attained.

General Requirements

The Doctor's degree is granted primarily on the basis of achievement, rather than on the accumulation of units of credit. However, the candidate is expected to have completed three academic years of residence in a graduate program beyond the Bachelor's degree. Generally, this is interpreted to mean a minimum of 135 quarter-units of graduate credit. Of these, a total of 45 may be earned as research credit for the Master's and Doctor's theses. Normally the remainder is earned through course work and independent study.

Residence: A minimum of eleven months' full-time study must be undertaken at the University for the doctorate. The residency time shall normally correspond to the period of the oral examinations and the completion of the thesis. This may be accomplished in one calendar year or four full-time summer terms.

Admission to Candidacy: Upon completion of the formal course program of studies, as approved by the Graduate Programs Committee, the students shall present themselves for comprehensive examinations on the subjects of their course work. The arrangements for the comprehensive examinations shall be initiated by the student through the Graduate Programs Committee.

Those students who have performed satisfactorily on the comprehensive examinations may apply for degree candidacy by submitting a formal letter of application to the Dean of the School of Engineering. This must be accompanied by a statement of intent of research supervision by the student's thesis advisor and a letter of recommendation by the Department Chair. It shall be the student's responsibility to arrange for a thesis advisor.

The comprehensive examinations normally must be completed within five years from the time which the student has been admitted to advanced standing. Comprehensive examinations may be repeated only once.

Preparation for Research: The Doctoral candidate shall request the thesis advisor and the Department Chair to form a Doctoral Committee. This committee shall consist of at least five members, including the thesis advisor and two additional members from the major department. The committee shall include two members from the Mathematics and/or Physical Science departments.

The Doctoral Committee shall determine language requirements, and any further studies which may be required.

Oral Examination: Within a period of three years after admission to candidacy, the student must normally make arrangements with the Doctoral Committee for the oral examination on his or her research and thesis. This examination shall be conducted by the Doctoral Committee and whomever they appoint as examiners. The thesis must be made available to all examiners one month prior to the examination. The oral examination shall consist of a presentation of the thesis, which shall not exceed forty minutes, and the defense of the thesis, which shall not exceed one hour. This examination shall be open to all faculty

members of the University of Santa Clara and shall be announced two weeks prior to the examination date.

Thesis: At least one month before the degree is to be conferred, the candidate must submit to the Dean of the School of Engineering two copies, ribbon or reproduced, of the thesis describing the research in its entirety. The thesis shall not be considered as accepted until it has been approved by the Doctoral Committee, and until one or more articles based upon it have been accepted for publication by an acceptable professional or scientific journal.

The requirements for the Doctor's degree by the School of Engineering have been made to establish the structure in which the degree may be earned. Upon written approval of the Academic Vice President, the Dean of the School of Engineering, and the Chair of the Department, other degree requirements may be established. The Faculty of the University reserves the right to evaluate both the undertakings and the accomplishments of the degree candidate in total and award or withhold the degree as a result of its deliberations.

INFORMATION FOR THE GUIDANCE OF ALL GRADUATE STUDENTS

Standards of Scholarship

Only courses in which the student has assigned grades of A, B, or C may be counted in satisfaction of the requirements for the Master's degree. The student must earn a 3.0 average in all courses taken at Santa Clara as a graduate student to be eligible for the degree. Only credits, and not grade-points, are transferred from other institutions. The Dean of the School of Engineering will request students to terminate enrollment when satisfactory progress towards a degree is not being maintained.

The minimum acceptable achievement is interpreted to mean:

35 units completed:	3.0 cumulative GPA
30 units completed:	2.95 cumulative GPA
25 units completed:	2.9 cumulative GPA
20 units completed	2.85 cumulative GPA
10 units completed	2.8 cumulative GPA

Readmission

An application for readmission is required of persons whose enrollment in the University lapses for two consecutive terms, excluding summer terms. A regular admission form will be used with the readmission status marked on it. Applicants for readmission must submit transcripts of the latest graduate work completed in other departments of the University, together with official transcripts of study completed elsewhere since the previous enrollment.

Academic Loads

It is recommended that work-study students limit their course load upon their initial registration to a maximum of four quarter-hours. Despite the convenience of the hours of class meeting, the additional time for study, plus other responsibilities, may lead to an overestimation of the quality of work that can be maintained under these conditions. Students enrolled under a work-study plan may not enroll for more than six quarter-hours. Students enrolling for more than six quarter-hours will be considered resident students and subject to the appropriate regulations.

Resident students with a research or teaching assistantship will not be allowed to enroll in more than twelve quarter-hours in any quarter, and no graduate student may exceed fifteen quarter-hours in any one quarter. Nine quarter-hours is considered the minimum load for full-time enrollment.

Repeating Courses

A student may, with the permission of the department, repeat a course in which a grade of C or lower was received on the first attempt. All grades, whether initially received, or on the second attempt, will be used in computing the overall student performance. The units from the repetition do not count towards filing graduating unit requirements.

Courses Completed at Other Institutions

A maximum of nine quarter-hours of credit may be transferred from other accredited institutions at the discretion of the Graduate Committee. Eligible courses include those taken as a registered graduate student in which a grade of B or better was earned.

Foreign Students

Admission to graduate study is based on records of undergraduate work. If this study was in a language other than English, the individual's ability to undertake a program wherein the instruction is in English is difficult to determine. The University will strongly encourage review courses in English and appropriate undergraduate courses, not for graduate credit, when it feels that an individual's progress is suffering because of a language difficulty.

A foreign student who is accepted for enrollment in the University of Santa Clara will receive a certificate of acceptance, which he must show to the consular officer of the United States to whom he applies for a student visa. Foreign students must maintain an enrollment level of at least ten quarter-hours each term.

Withdrawal From the University

Withdrawal from the University is not officially complete until students clear all of their financial obligations with the Office of Student Accounts. Students on deferments or National Direct Student Loans must also clear their financial obligations with the Office of Credit and Collections.

TUITION AND FEES

Application Charge	**$25.00**
This charge is to be sent with each application form and is not refundable.	
Tuition, per quarter hour for all courses, including Thesis	**115.00**
Late Registration Fee	**10.00**
Auditing Fee, per quarter hour for all courses	**100.00**
Comprehensive Written Examination Fee	**10.00**
Dissertation microfilming, Ph.D	**25.00**
Diploma and graduation fee	**30.00**
Transcript of grades (rush process) fee	**7.50**
Deferment Service Fee	**10.00**
Returned Check Fee	**10.00**
Charge Card Returned Item Fee (returned unpaid from your VISA or Mastercharge agency)	**5.00**

Method of Payment

Students should come prepared to pay all charges on the day of registration. Remittances should be made payable to the University of Santa Clara. Information regarding periodic statement of account or payment should be directed to the Office of Student Accounts.

Students who have unpaid bills at the University or who defer payment without signed approval are subject to dismissal from the University and, as long as such payments remain unpaid, may not receive transcripts of credit nor any diploma.

There are several tuition plans administered by outside financing agencies which are available. Those who plan to avail themselves of one of these plans should request information from the Office of Student Accounts at least three months prior to registration.

Refund of Tuition

Any student formally withdrawing after he or she has registered but prior to the first scheduled meeting of the class will receive a full refund minus a $10.00 registration cancellation fee. Any student formally withdrawing prior to the fourth meeting of any regularly scheduled class will receive a refund of one-half of the tuition for that class. No refunds will be made subsequent to the fourth meeting. The date on which written notice of withdrawal is received by the Dean of the School of Engineering will determine the refund, not the date of last attendance by the student. Appeals for special consideration should be addressed to the Graduate Committee for Engineering and forwarded to the Graduate School of Engineering Office. No refunds will be made by virtue of curtailment of services brought about as a result of strikes, acts of God, civil insurrection, riots or the threat thereof, or other causes beyond the control of the University.

Financial assistance at the University of Santa Clara is awarded on the basis of superior academic record, and/or financial need. Assistance generally is categorized as scholarships, loans, deferred payment plans and jobs.

Loans

Because scholarships and grants are limited, many students applying for aid find the most advantageous method of financing their education through a loan program. Among those available to students of the Graduate School of Engineering are the National Direct Student Loan program, and Guaranteed Student Loans. Application forms and further information may be obtained from the Office of Financial Aids.

Scholarships

Besides the conditions laid down by the donors, all scholarships administered by the University are subject to the following conditions:

1. In selecting students for scholarship benefits, evidence of financial need is required. From the applicants who satisfy this requirement, preference will be given to students with higher scholastic attainments.
2. A student who holds a scholarship must file a petition for renewal each year. Petitions for new or renewed scholarships by students already in attendance at the University must be submitted before February 1.
3. Scholarships may be cancelled at any time for serious infractions of the rules and regulations of the University.
4. As a general rule, undergraduate applicants receive priority consideration for the different financial aids for which both graduate and undergraduate students are eligible to apply.
5. As a general rule, the University does not maintain a scholarship or grant program for students enrolled in the Graduate School of Engineering.

California State Graduate Fellowships

State Graduate Fellowships are awarded to students pursuing a recognized graduate or professional degree and who have not completed more than four quarters of full-time graduate work as of October 1. Selection is made on the basis of State manpower needs, academic performance and financial need. Applications are available in the fall from either the Graduate Fellowships or Financial Aids Offices.

Deadlines

The office of Financial Aids has established deadlines for consideration for the various programs it administers. All students requesting financial aid from the University should contact the aid office at the earliest possible date and request specific deadline information and appropriate application materials. A University application for financial aids is required. Files completed later than May 1 will receive consideration on a funds available basis.

Veterans and Veterans' Dependents Assistance

The University of Santa Clara is listed by the Veterans Administration as qualified to receive students under Chapter 34 (veterans). Chapter 35 (veterans' dependents—son or daughter with parent deceased or 100% disabled; widow of any person who died in the service or died of a service connected disability, or the wife of a veteran with a 100% service-connected disability) and Chapter 31 (rehabilitation). Those interested in attend-

ing under any of these chapters should contact the Veterans Administration Office in their locality to determine eligibility for benefits.

The State of California provides a program for children of veterans who are deceased or disabled from service-connected causes. Application should be made to the California Department of Veterans Affairs, 350 McAllister Street, San Francisco, CA 94102.

Information regarding these programs may be obtained from the University of Santa Clara veterans' counselor located in the Registrar's Office, Delia Walsh Hall.

STUDENT DEVELOPMENT SERVICES

A variety of services is offered to students through Student Development Services. A professional staff of educators, psychologists, and guidance specialists helps students enrich their educational and professional development. Programs are designed to facilitate the growth of students beyond the classroom environment.

Career and Personal Counseling

There are several counselors available to assist students with their career and personal development needs (Benson Center, second floor). Both individual and group opportunities are provided. A variety of personal skill-building workshops is also offered to students, as well as individual career planning and counseling.

NONDISCRIMINATION POLICY

The University of Santa Clara admits students of any race, religion, sex, color, handicap, national and ethnic origin to all the rights, privileges, programs, and activities generally accorded or made available to students at the school. It does not discriminate on the basis of race, color, religion, sex, handicap, national and/or ethnic origin in administration of its educational policies, admissions policies, scholarships and loan programs, and athletic and other school-administered programs. Additional information and copies of the Grievance Procedures are available in the Office of Student Services and/or the Personnel Department.

STUDENT RECORDS

The University policy relating to student records complies with the Family Educational Rights and Privacy Act of 1974 (Buckley Amendment). Accordingly, the University will release "directory information" to any person upon request, unless a student requests in writing that "directory information" be held private. "Directory information" is designated as:

Students' names,
Sex,
Address (campus. local, and/or permanent),
Telephone number,
Date and place of birth,
Major field of study, class, dates of attendance, degrees, and honors received,
Most recent previous educational institution attended,
Participation in officially recognized activities, including intercollegiate athletics,
Name, weight, and height of participants on intercollegiate athletic teams.

During the fall registration and the academic year in the office of the Vice President for Student Services, students may request in writing that "directory information" be held private. Once filed, the request remains in effect for the remainder of the academic year.

The following types of records are excluded from inspection by provisions of the law; namely those created or maintained by a physician, psychiatrist or psychologist in connection with the provision of treating a student. A Parents' Confidential Statement of the College Scholarship Service is also excluded under the same provision. Third parties shall not have access to education records or other information pertaining to students without the written consent of the particular student about whom the information is sought.

Students may inspect their records at the following offices:

a. Official academic records, including application forms, admissions transcripts, letters of acceptance and a student's Permanent Academic Record are on file and maintained in the Registrar's Office.
b. Working academic files are also maintained by each Dean of a School or College in their respective offices.
c. Records related to a student's non-academic activities are maintained in the Office of the Vice President for Student Services.
d. Records relating to a student's financial status with the University are maintained in the Office of Student Financial Services.

A written statement on inspection policies, list of fees for copies and related information is available in each office containing student records. Complaints regarding academic records by students may be directed to the Dean of the College or School in which the student is enrolled.

Students having questions regarding the policy on the privacy of records should contact the University Registrar (Walsh Administration Building).

STUDENT HOUSING

The University maintains twelve dormitories for undergraduate students.

Dormitory accommodations are not available for graduate students. Inquiries regarding off-campus housing should be sent to: Director of Housing Services, University of Santa Clara.

APPLIED MATHEMATICS

Gerald Markle, Ph.D., *Chair*
Professor: Gerald Markle

Undergraduate Courses

106. Differential Equations
First order and simple higher order ordinary differential equations, applications: linear differential equations with constant coefficients and their applications: linear differential equations with variable coefficients; systems of differential equations; Laplace transforms basic theorems, solution of differential equations by Laplace transforms.

108. Probability and Statistics
Definitions of probability, sets, sample spaces, conditional and total probability, random variables, distributions, functions of random variables, sampling, estimation of parameters, testing hypotheses.

118. Numerical Methods
Solution of algebraic and transcendental equations, finite differences and interpolation, numerical differentiation and integration, numerical solution of differential equations, method of least squares. Programming of representative problems. Prerequisite: ability to program in ALGOL or FORTRAN.

Graduate Courses

All applied mathematics courses on the 100 level are assumed to be first-year graduate courses. The minimum preparation for these courses is a working knowledge of the calculus and a course in differential equations. A course in advanced calculus is desirable. The 200 level courses are graduate courses in mathematics which should only be taken by students who have completed several 100 level courses.

110. Introduction to Probability I (2)
Definitions, sets, conditional and total probability, the binominal distribution approximations, random variables, important probability distributions, functions of random variables, moments, characteristic functions, joint probability distributions, marginal distributions, sums of random variables-convolutions, correlation, sequences of random variables, limit theorems.

111. Introduction to Probability II (2)
Continuation of 110.

114. Engineering Statistics I (2)
Frequency distributions, sampling, sampling distributions, univariate and bivariate normal distributions, analysis of variance, two- and three-factor analysis, regression and correlation, design of experiments.

115. Engineering Statistics II (2)
Continuation of 114.

120. Numerical Analysis I (2)
Solution of algebraic and transcendental equations, finite differences, interpolation, numerical differentiation and integration, solution of ordinary differential equations, matrix methods with applications to linear equations, curve fittings, programming of representative problems.

121. Numerical Analysis II (2)
Continuation of 120.

125. Vector Analysis I (2)
Algebra of vectors. Differentiation of vectors. Partial differentiation and associated concepts. Integration of vectors. Applications. Basic concepts of tensor analysis.

126. Vector Analysis II (2)
Continuation of 125.

130. Applied Mathematics I (2)
Hyperbolic functions, elliptic integrals, power series solution of differential equations, special functions.

131. Applied Mathematics II (2)
Orthogonal functions, Fourier series, Euler's equations, even and odd functions, half-range functions, Laplace transforms, basic transforms, application. (Note: 130 and 131 may be taken in either order.)

132. Applied Mathematics III (2)
Partial differential equations, separation of variables, Laplace transform methods applied to the solution of partial differential equations. Prerequisites: A.M. 130 and A.M. 131.

135. Complex Variables I (2)
Algebra of complex numbers, calculus of complex variables, analytic functions, harmonic functions, power series, residue theorems, application of residue theory to definite integrals, conformal mappings.

136. Complex Variables II (2)
Continuation of 135.

140. Modern Algebra I (2)
Introduction to postulational systems, integers as an integral domain, study of rational, real and complex number fields, polynominal forms and functions, introduction to group theory, vectors and vector spaces, algebra of matrices, rings and ideals.

141. Modern Algebra II (2)
Continuation of 140.

145. Linear Algebra I (2)
Vector spaces, transformations, matrices, characteristic value problems, canonical forms and quadratic forms.

146. Linear Algebra II (2)
Continuation of AM 145.

178. Environmental Models I (2)
Mathematical modeling of environmental and ecological systems. Emphasis on the quantitative description of the following phenomena: Dispersal of air and water pollutants, noise pollution phenomena, thermal pollution from nuclear power generation and long term geophysical effects.

179. Environmental Models II (2)
Continuation of A.M. 178. Dynamics of populations. Criteria for extinction, stability and unstable growth of human, animal and plant species. Interrelations of different species and the physical environment. Special attention will be given to examples from the San Francisco Bay Area.

180. Combinatorial Mathematics I (2)
Permutations, combinations, partitions, enumeration methods generating functions, evaluation of discrete sums, and introduction to graph theory. Recurrence relations, solution of difference equations, the principle of inclusion and exclusion, Polya's theory of counting. Applications. Knowledge of matrices suggested.

181. Combinatorial Mathematics II (2)
Continuation of 180.

205. Advanced Numerical Analysis I (2)
Numerical solution of partial differential equations, finite difference methods, Monte Carlo techniques, relaxation methods, programming of representative problems. Prerequisites: 120, 121 and ability to program in FORTRAN.

206. Advanced Numerical Analysis II (2)
Matrix computations, eigen values of finite matrices, application of matrix methods to the solution of systems of linear equations, programming of representative problems. Prerequisite: 120, 121 or equivalent.

215. Matrix Theory I (2)
Properties and operations, vector spaces and linear transforms, characteristic roots and vectors, inversion of matrices, applications. Prerequisite: 145.

216. Matrix Theory II (2)
Continuation of 215.

230. Advanced Applied Mathematics I (2)
Functional spaces, vector and matrices, systems of orthogonal functions, linear spaces, manifolds, linear operators, spectral theory, functions of operators and matrices. Green's functions, delta functions, differential operators, eigen function representation of operators, perturbation methods, operators for partial differential equations.

231. Advanced Applied Mathematics II (2)
Continuation of 230.

232. Advanced Applied Mathematics III (2)
Continuation of 231.

233. Non-Linear Differential Equations I (2)
Theory of non-linear equations, existence of solutions, uniqueness of solutions, first order equations, second order equations, special methods, non-linear integral equations. Periodic solutions and asymptotic methods. Prerequisites: 137 and 145.

234. Non-Linear Differential Equations II (2)
Continuation of 233.

236. Tensor Analysis
Algebra and calculus of tensors applications in engineering and science. Prerequisite: AM 126.

240. Linear Programming I (2)
Basic assumptions and limitations, problem formulation, algebraic and geometric representation, Simplex Algorithm, and duality.

241. Linear Programming II (2)
Network problems, transportation problems, production problems. Continuation of 241.

246. Graph Theory I (2)
Introduction to graph theory; Euler paths and their applications; Hamiltonian circuits; trees, circuits and cut-sets; shortest path problems; planarity and duality; matching theory; directed graphs. Prerequisite: knowledge of matrix theory.

247. Graph Theory II (2)
Continuation of A.M. 146.

250. Mathematical Statistics I
Mathematical theory of statistics fundamental concepts, principles of estimation, sampling distributions. Multivariate statistics and regression theory.

251. Mathematical Statistics II
Continuation of AM 250.

258. Fourier Transforms (2)
Elementary concepts from topology. Fourier transforms of summable functions, convolution theory, elementary theory of distributions. Applications.

262. Stochastic Processes I (2)
Types of stochastic processes, stationarity, ergodicity, differentiation and integration of stochastic processes, correlation and power spectral density functions, linear systems, band limit processes, estimation, nonstationary processes, normal processes, Markov processes. Prerequisite: AM 111.

263. Stochastic Processes II (2)
Continuation of 262.

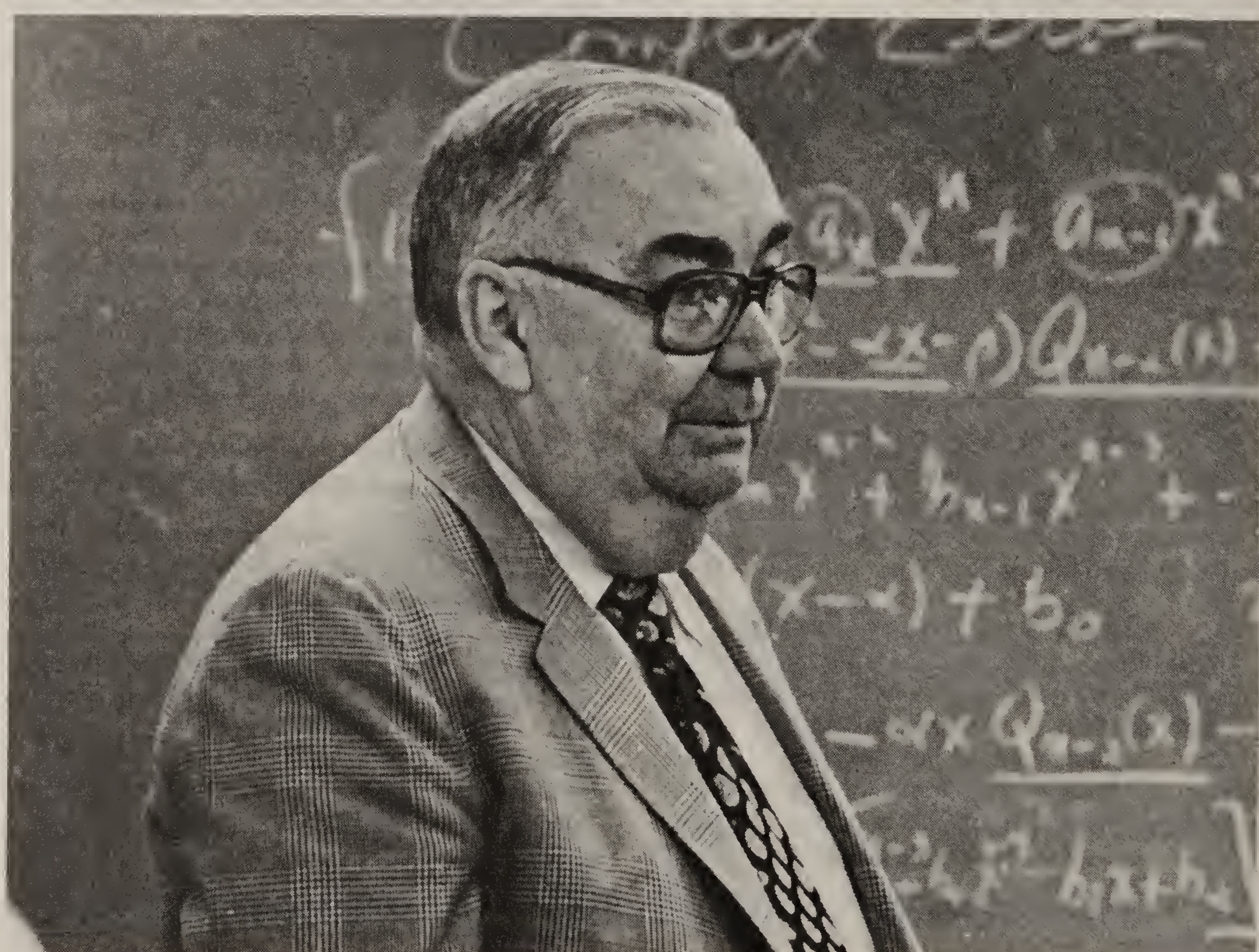
270. Optimization Techniques I (2)
A study of optimization techniques with emphasis on experimental methods. Necessary and sufficient conditions for extreme of functions. One-dimensional search methods. Steepest ascent, partan, conjugate gradiente and ridge-acceleration techniques. Prerequisite: Ability to program in Fortran.

271. Optimization Techniques II (2)
A study of optimization problems involving equality constraints and inequality contraints by gradient and non-gradient methods.

274. Partial Differential Equations I (2)
Relation between particular solutions, general solutions and boundary values. Existence and uniqueness theorems. Wave equation and Cauchy's problem. Potential theory and Dirichelet's problem. Heat equation. Prerequisite: AM 130, 131.

275. Partial Differential Equations II (2)
Continuation of 274.

299. Special Problems (1 to 2 units)
By special arrangement.



CIVIL ENGINEERING AND ENGINEERING MECHANICS

Joseph J. Fedock, Ph.D., *Chair*

Associate Professors: E. John Finnemore, Harold M. Tapay
Assistant Professor: Joseph J. Fedock
Acting Assistant Professor: Charles W. Unsell

In the Civil Engineering Department, the field of Engineering Mechanics is emphasized at the graduate level. The focus of the educational effort is on the analytical methods used to formulate the behavior of structural and other engineering systems; this behavior is also investigated by experimental methods. Advanced topics which deal with the static and dynamic response of rigid and deformable bodies are studied in the program.

115. Materials Engineering
Origin, manufacture, and processing of materials used in civil engineering. Physical properties of metals, wood, plastics, cement, concrete and other engineering materials. Corrosion and its prevention. Fire resistance, heat transmission.

118. Construction Engineering 1
Construction management. Licensing. Drawings and specifications. Cost analysis, estimating and bidding. Contracts. Bonds. Financing. Insurance. Labor Legislation. Project planning and scheduling.

121. Soils Engineering
Origin, development and properties of soils. Classification of soils and applications of physics and engineering mechanics to soil as an engineering material. Water in soils. Compaction, stabilization, consolidation, shear strength and bearing capacity. Occasional laboratories. Prerequisites CE 20 and E 43.

130. Statically Determinate Structures
Member actions and displacements are found for statically determinate structures. Continuous beams, trusses, frames, and arches are considered. Deflections are computed using direct integration for continuous beams and using energy methods for all structures. Steel design laboratory. Prerequisite: E 43.

131. Statically Indeterminate Structures
Statically indeterminate structures are analyzed by both the flexibility and stiffness methods. Continuous beams, trusses, frames, and arches are considered. In addition, frames are analyzed using moment distribution. Matrix methods of structural analysis are introduced. Steel design laboratory. Prerequisite: CE 130.

133. Timber and Prestressed Concrete Design
Design of timber structures, and design of prestressed concrete structures. Particular attention will be given to the design of connection details. The complete design of simple structures made of both materials will be required. Occasional laboratories. Prerequisite: CE 130 and CE 135.

135. Reinforced Concrete Design
Analysis and design of reinforced concrete structural elements using the Ultimate Strength and Working Stress Methods. Design of elementary structures, e.g. one story building, retaining walls. Introduction to the theory of pre-stressed concrete. Prerequisite: CE 130.

136. Advanced Concrete Design
Theory and practice of the design of bridges and other concrete structures. Design of prestressed concrete members. Prerequisite: CE 135.

137. Fundamentals of Earthquake Engineering
Causes and characteristics of earthquake motions. Introduction to the dynamics of single and multi-degree-of-freedom lumped mass systems. Introduction to finite element modeling of framed structures. Idealization of real structures and analysis of idealized models by time-history and response spectrum methods. Special considerations for earthquake resistant design of steel, timber, and reinforced concrete structures. Prerequisite: CE 131.

138. Foundation Engineering
Surveying, mapping, and foundation exploration; slope stability and settlement analysis; spread foundations; piles and cassions; earth-retaining structures; loads on underground conduits; subsurface construction. Prerequisites: CE 121 and CE 135.

139. Hydrology and Drainage
Precipitation, evaporation, transpiration, runoff, and infiltration. Drainage areas, concentration points, storage, and floods. Stream-flow hydrographs and routing. Street, highway, and airport drainage. Occasional laboratories. Prerequisite: E 120.

140. Water Resources Engineering

Concepts of various aspects of water resources: storm and flood waters, ground waters, water supply and distribution, sewage collection and disposal, and irrigation. Interrelationship of all aspects: Importance of water resources to the environment. Importance of water resources to the total needs of the community. Prerequisites: CE 20 and E 120.

141. Hydraulic Engineering

Principles of hydraulics; flow in pipes and pipe networks; water hammer and surge tanks; steady flow in open channels, including bends and transitions. Design of closed conduits and open channels. Prerequisites: E 120 and Senior standing.

142. Water Resources Design

Design of storage facilities, water distribution systems, storm and sanitary sewer systems, treatment plants, and swimming pools. Prerequisites: CE 140.

143. Environmental Engineering

Public control of water-born and air-born diseases; vector and weed control; pesticides; food protection. Management of solid wastes; air pollution control; water quality control. Recreational facilities and the residential environment. Planning, organizing, and managing environmental programs. Prerequisites: Biology 9 or Chemistry 2 or equivalent. Junior or senior status.

144. Environmental Planning

Physical and esthetic features of the environment and their influence on planning. Soil, geologic, and flooding hazards. Preservation of open space and amenities. Air quality; water quality, congestion. Applications to project planning. Prerequisite: Junior or senior status.

145. Transportation Engineering

Transportation as a system to meet the needs of society in movement of people and goods. Interaction between transportation facilities and the community. Engineering aspects of rail, highway, air, and water carriers and routes. Modern concepts and technology. Prerequisites: CE 10 and Senior standing.

146. Urban and Regional Planning

Principles of city and regional planning. Organization and functioning of planning agencies. Urban and regional problems and their influence on planning. Features of general plans. Prerequisite: Junior or senior status.

147. Pavement Design

Paving Materials. Geometric and structural design of highways. Urban street layout and details. Layout and design of airport runways, taxiways, and aprons. Pre- or co-requisite: CE 121.

148. Construction Engineering II.

Construction methods and equipment. Earth moving and concrete construction. Planning and scheduling. Construction site organization. Prerequisite: CE 130.

197. Independent Study

Open to departmental scholars only.

205. The Theory of Finite Element Methods (2)

Introduction to the finite element method. Force and stiffness methods. Matrix methods of analysis. Stiffness matrix formulation for axial and bending members. Local and global stiffness matrices. Transformation of stiffness matrices.

206. Finite Element Methods II. (2)

Energy methods. Displacement functions for structural members. Derivation of load vectors. Analysis of plane stress and plane strain problems. Area coordinates. Constant strain triangle. Isoparametric elements. Prerequisite: CE 205.

207. Finite Element Methods III. (2)

Application of finite element method to dynamics of elastic and inelastic bodies. Mass matrices. Analysis of plates and shells. Development of computer code based on finite element theory. Prerequisite: CE 206.

209. Thin Plates and Shells (4)

Methods of analysis of plates of various shapes under various loading and support conditions. Fourier series solutions, energy methods, and numerical finite difference methods. Membrane theory of shells of revolution. Bending theory of cylindrical shells.

211. Advanced Strength of Materials (4)

Bending of beams with nonsymmetrical cross section. Curved Beams. Shear Center. Shear Flow in open and closed sections. Torsion of open and closed section members. Energy theorems and their applications. Beams on elastic foundations. Beam analysis using Fourier Series. Stress analysis of composite materials.

214. Theory of Elasticity (4)

Analysis of stress and strain using cartesian tensors. Compatibility conditions and the uniqueness theorem. The tensor stress function and Boussinesq-Papkovitch displacement potentials. Applications to boundary-value problems in three-dimensional elasticity.

216. Theory of Plasticity (4)
Stress and strain analysis of members whose material is loaded beyond the plastic limit. Perfectly plastic materials. Yield hinges. Yield criteria, slip-line folds. Elasto-plastic analysis of spheres and cylinders. Creep behavior of materials.

217. Advanced Theory of Shells (2)
Bending theory of shells. Stress function and numerical methods in shell analysis. Shells of negative curvature and shallow shells. Shells of variable thickness. Prerequisite: CE 209.

218. Dynamics of Structures (4)
Analysis and behavior of simple linear oscillators. Natural mode shapes and frequencies for distributed and lumped mass systems. Introduction to non-linear vibrations.

221. Stability of Structures (4)
Elastic stability of columns under axial loads and bending moments. Introduction to inelastic stability analysis of columns. Stability analysis of frames. Stability of flat plates and cylindrical shells. Lateral buckling of beams.

222. Statically Indeterminate Structures (4)
Advanced methods for the analysis of statically indeterminate structures. Comparison of analysis methods. Analysis by approximate methods, energy methods, and the flexibility and stiffness finite element methods suitable for analysis on digital computers.

227. Experimental Stress Analysis (2)
Theory and practice of the Photo-elastic and Moire methods for determining stresses. Photoelastic coatings. Electrical, mechanicl and optical strain gages.

228. Mechanics of Fracture of Solids (2)
Elastic and elastic-plastic fracture criteria. Stress intensity solutions. Metallurgical aspects of toughness. Design and alloy selection. Failure analysis techniques applied to actual engineering problems.

229. Advanced Mechanical Properties of Materials (2)
Theories of failure for engineering materials. Mechanical properties of engineering materials at low and elevated temperatures. Fatigue and creep behavior. Effect of radiation on mechanical properties.

230. Random Vibrations (2)
The response of a single-and multi-degree of freedom linear systems to random loadings is studied. The random vibrations studied are restricted to being stationary and ergodic. Correlation functions and spectral densities of the response are found in terms of system properties as well as correlations and spectral densities of the input. Responses involving cross-correlations are also studied. Prerequisite: CE 218.

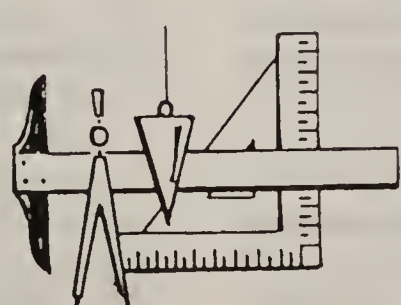
235. Theory of Wave Propagation I. (2)
Introduction to wave propagation. Development of general equations of motion and the reduction to the wave equations. Propagation of waves in anisotropic and isotropic media and their reflection and reaction at boundaries.

236. Theory of Wave Propagation II (2)
Study of the physical characteristics of Rayleigh and Love waves. The three-dimensional frequency equation and spectrum for plane waves. Prerequisite: CE 235.

237. Shock Waves in Solids II (2)
Thermodynamic constitutive relations for solids, thermodynamic effects in shock propagation, strain rate effects, the concepts of wave propagation in three dimensions. Discussion of current research.

240. Composite Structures (4)
Lamination theory. Constitutive relationships. Laminate failure behavior. Testing of composite materials. Theory and design of adhesive and bolted joints. Structural behavior of composites.

299. Directed Reading, Thesis, or Directed Research



ENGINEERING

Robert J. Parden, Ph.D., *Coordinator*

3. Introduction to Computing
Basic computer concepts and organization, the concept of an algorithm. Discussion and examples of problem solving techniques, programming style, and program documentation methods. FORTRAN, hands-on computer experience. Open to non-engineering students. Prerequisite: High school algebra.

41. Mechanics I (Statics)
Resolution and Composition of force systems and equilibrium of force systems, acting on structures and mechanisms. Introduction to stress and strain analysis. Prerequisite: Physics 4.

42. Mechanics II (Dynamics)
Dynamics of a particle and dynamics of rigid bodies. Introduction to theory of vibrations. Prerequisite: Mechanics I.

43. Mechanics III (Strength of Materials)
Analysis of stresses and strains in bodies undergoing various leading conditions. Energy theorems and their applications. Laboratory. Prerequisite: Mechanics I.

101. Principles of Electrical Circuits
The physical basis and mathematical models of circuit components and energy sources are introduced. Circuit theorems and methods of analysis are applied to D.C. and A.C. circuits. Laboratory. Prerequisites: Math 21, Engineering 41.

102. Principles of Electronic Circuits
Introduction to electronic devices. Analysis of linear and non-linear electronic circuits—containing diodes and transistors. Operational amplifiers. Introduction to digital circuits. Laboratory. Prerequisite: Engineering 101.

103. Principles of Electrical Machines
Magnetic circuits, transformers, DC and AC generators and motors. Prerequisite: Engineering 101.

120. Thermofluid Mechanics I
An integrated study of the fluid mechanics and thermodynamics of engineering systems. Laboratory. Prerequisite: Engineering 41.

121. Thermofluid Mechanics II
A continuation of Engineering 120. Laboratory. Prerequisite: Engineering 120.

132. Engineering Economics and Management
Economic systems. Time value of money. Basic techniques of economic analysis of engineering projects. Planning and capital budgeting. Business organizations. The Engineering manager.

200. Electrochemistry (2)
Electrochemical energy conversion, corrosion, desalination and solid state electrochemistry. For all engineering disciplines.

201. Modern Atomic Theory and Engineering Applications (2)
A survey of the modern theory of the nature of atoms, molecules and nuclei. An introduction to quantization and atomic spectra. Applications to X-rays, lasers, superconductivity. Satisfies one physical science requirement for electrical engineers.

205. Plasma Physics and Controlled Thermonuclear Fusion (2)
Basic relationships and experimental techniques are emphasized.

206. Introduction to Atomic and Molecular Spectroscopy and Their Applications (2)
Discussion of origins of atomic and molecular spectra will be followed by their application to spectrochemical analysis, pollution monitoring, plasma physics and lasers. Experimental techniques and instrumentation will be discussed.

207. Elements of Lasers and Their Engineering Applications (2)
Fundamentallaser design, associated optics, and the properties of laser beams will be discussed. Specific laser systems will be considered as examples. Application of lasers to various fields will be discussed, for example, holography, interferometry, hole-drilling and others.

210. Bioengineering I — Physiological System (2)
A quantitative approach to the structure and function of mammalian systems.

211. Bioengineering II — Physiological Systems, Measurements and Modeling (2)
Experimental techniques of investigation with emphasis on instruments and modeling.

212. Bioengineering III — Physiological Systems, Measurements and Modeling (2)

ENGINEERING MANAGEMENT

Robert J. Parden, Ph.D., *Coordinator*

250. Introduction to Engineering Management (2)
When technical specialists become managers they: plan, create strategies, make decisions, organize, select people, delegate, set standards, allocate resources, communicate, coordinate, appraise performance, feedback appraisal, lead, create a motivating climate, reward performance, manage conflict and change, and develop people.

252. Strategic Planning for Managers of Technology (2)
Team centered approach, multi-level study groups, situational analysis, assessing the environment, attainable objectives, strategy alternatives, selecting the best one, action plans for implementation.

253. Operating Systems (2)
Production planning, scheduling and control; quality assurance, performance standards; inventory control; design manufacturing communications, the management of product servicing.

254. Organizations: Function, Structure, Climate (2)
Organizational design; alternatives; functional vs. matrix organization; designing a matrix system; impact on motivational climate.

255. Accounting and Cost Control for Project Managers (2)
The accounting records; debit-credit process; recording transactions; from transactions to statements; balance sheet; income statement; funds flow statement; costs; project cost controls.

256. Finance and Budgeting for Engineering Managers (2)
Profit planning; return on investment; accounting conventions; evaluation of economic alternatives; break even analysis; tax environment; capital budgeting, performance budgeting; cash flow; inventory policy; capital structure; security markets; financial controls; finance in general management.

257. The Business Environment (2)
The economy; the price system; business cycles, money and banking, securities markets, business organizations, the corporation, business functions; marketing, technology, finance and operations.

258. Creative and Analytical Decision Making (2)

The nature of the decision process; identifying the real problem; assessing your approach to decision making; quantitative parameters in decision problems; factors affecting the choice between options; specified decisions based on models; sensitivity analysis; functional applications of decision making techniques; specifying information for computer assistance.

261. Technical Products and Profits (2)

Organizing a technical firm. A business plan. Integrating marketing, finance, design, manufacturing, and service systems.

262. Managing Projects and Programs (2)

The role of the Project Manager; evaluating and selecting projects; the profit concept; project organization; initiating the project; developing a schedule; the systems approach; managing the project; identifying major problems; progress control schedule and performance; earned value and trend analysis; transferring the completed project; preparing and presenting a budget plan; monthly budget targets; management reporting; controlling a change.

263. Marketing of the Technological Projects and Systems (2)

Product planning, marketing research, demand analysis, product strategies, service organizations, pricing strategies, inventory planning, distribution, a marketing plan, product life cycles, sustaining user-inside manager communications.

264. Managing Research and Development (2)

The role of R & D in corporate growth; unique characteristics of R & D management; financing applied research; measuring return on investment; planning for diversification; the structure of R & D organizations; the choice of an R & D portfolio; idea generation process; selecting projects and establishing objectives; developing technical personnel; motivation of personnel; technical assistance to R & D staff; planning, scheduling and control; project budgets and controls; performance appraisal; leadership in research organizations.

266. Stress Reduction and the Catalyst for Creativity (2)

Stress as both an inhibitor and as a source for creativity at work and in everyday living. Effective means of identifying, channeling, and alleviating stress for the engineering manager.

268. Interpersonal Relations in Engineering Management (2)

The dynamics of human interaction and communication. Personal communication styles; new patterns of exchange and new approaches to interfacing with others.

269. Human Resources Development and the Engineering Manager (2)

Concepts of human resource management; the meaning of work; the individual and the organization; growth and learning; the manager's role career/life management; human resource strategies.

270. Effective Oral Technical Presentations (2)

The role of communications; persuasive communications; speaking as a meeting leader; substitutes for reading speeches; purposes and effects; selling your ideas to one or more persons; how to make meetings work.

271. Effective Written Technical Communication I (2)

Cluster writing; pyramid technique; audience analysis; opening, body and end of text; technical correspondence; abstracts and summaries, and presentation patterns for reports and proposals; proposal presentation.

272. Effective Written Technical Communication II (2)

Overview of writing techniques; mechanics of style and editing techniques; instructional and procedural publications; technical and management reports; technical papers, articles and news releases; proposals; technical sales literature.

273. Group Dynamics in Project Management (2)

Managerial styles and the effect on group dynamics. The literature on group processes will be studied and managerial styles will be tested in a laboratory setting.

274. Recruiting, Interviewing, and Selecting the Technical Team

Manpower planning, caliber aspirations, locating potentials, testing, interviewing, legal pitfalls, pre-employment screening, employee processing, orientation.

275. Innovation, creativity and Engineering Design (2)

Research, exploratory development, advance development, engineering development; the process of discovery; changing the status quo; recognizing a need; identifying creative talent; tradition vs. innovation; risks involved, involving new concepts; encouraging change; technological feasibility; manufacturing methods; inventions and their applications; marketability; the environment for innovation; creativity and the reward system; assertive training and creativity.

276. Introduction to Computer Systems (2)

Fundamental concepts of modern computer systems; design of industrial information systems including hardware selection, software design, human/machine interface, and data processing economics.

277. Introduction to Information Systems (2)

Basic concepts and uses of information systems in organizations. Fundamental design considerations. The role of data processing.

278. Computer Systems for Project Scheduling and Control (2)

The specification and configuration of computer-based systems for management applications. Methods for costing system hardware and software and for assessing computer performance. Trade-off analysis of comparative computer configurations.

279. Management of Computer-Based Information Systems (2)

An in-depth coverage of the problems in managing computer-based information systems. Focuses on the definition, evaluation, installation, and continuing management of EDP systems. Issues of planning and control, as well as the organizational impact of computer systems, are stressed.

280. Systems Analysis for Computer-Based Information Systems (2)

The detailed design and specification of computer-based management information systems. Includes studies of existing systems, economic and organizational analyses of alternatives, and tools for determining user requirements.

281. Telecommunications and Computer Networks (2)

Distributed processing. Networked minicomputer systems. Data communication technology. Data security in computer networks. Cost benefit analysis for the design, configuration, and implementation of computer networks.

282. Computer Aided Manufacturing (2)
Numerical control fundamentals, components and systems; human-computer-machine interfaces; numerical control programming, mathematics and optimization; computer aided manufacturing systems.

293. Current Papers in Engineering Management (2)

295. Seminar

299. Research M.S. Thesis/Special Problems (1 to 7 units)

ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Shu-Park Chan, Ph.D., *Chair*

Professors: Shu-Park Chan, Timothy J. Healy, Henry P. Nettesheim, Dragoslav Siljak, Raymond B. Yarbrough

Associate Professors: Daniel W. Lewis, Jack A. Peterson

Assistant Professors: Ronald L. Danielson, Ruth E. Davis

15. Advanced Programming
Discussion of data structures (arrays, trees, lists, etc.) and algorithms (searching, sorting), and the implementation of both using high-level programming languages. Procedures, scope of variables; use of iteration and recursion; techniques for structured programming. The principal language used in PASCAL. Prerequisite: E 3 or equivalent.

22. Machine Organization and Programming
Assembly Language programming. Introduction to computer architecture: number systems and representation, memory organization, computer organization; computer arithmetic; input/output impact of computer hardware or software. Introduction to assembler techniques. Prerequisite: EECS 15.

104. Electromagnetic Fields
Study of static and dynamic electric and magnetic fields. Dielectric and magnetic material properties. Maxwell's equations. Plane electromagnetic waves. Prerequisite: E 101.

105. Electromagnetic Waves
The continuation of 104. The propagation of waves as governed by Maxwell's equations are studied. Wave penetration, fundamental wave guides and antennas are included. Prerequisite: EECS 104.

103. Microwave Theory and Techniques
A combined lecture and laboratory course covering generation, propagation, and detection of microwave energy. Experiments on klystrons, impedance measurements, antenna radiation patterns, and the characteristics of passive microwave devices. Laboratory. Prerequisite: EECS 104.

111. Matrix Analysis of Networks and Systems
Review of Matrix algebra, elementary network topology, matrix formulation of system equations, network theorems. Laplace transform techniques, sinusoidal steady-state analysis, frequency response plots, two-port network theory, active two-port devices, state-space analysis methods, computer-aided analysis. Prerequisite: E 101.

112. Modern Network Synthesis and Design
Design of linear and non-linear operational amplifier circuits. Approximation. Synthesis of passive 1-ports and 2-ports. RC active filter design. Introduction to Linear ICs: PLL and waveform generators. Design Project. Prerequisite: EECS 111.

114. Introduction to Topological Analysis
Topological analysis of passive one-port and two-port networks, flowgraph techniques for the analysis of linear systems, active one-port and two-port analysis, and other engineering applications. Prerequisite: EECS 111.

121. Digital System Design and Analysis
Basic switching concepts. The concept of logical signals. Survey of digital logic circuits including MSI circuits. Number systems. Digital representation of information. Boolean algebra. Switching network description.

122. Computer System Organization and Design
Integrating large numbers of digital modules into a complete automatic computing system. Magnetic core and LSI semiconductor memory systems. Hardware sequences; microprogramming approaches. Input/output subsystem organization and management; interrupt-driven and DMA transfers. Prerequisites: EECS 22 and 121.

123. Theory and Translation of Computer Languages
The theory and detailed characteristics of high-level languages to facilitate man-computer communications. Lexical analysis, procedures for symbol table management and look-up, memory allocation, syntactic and semantic analysis, and code generation. Elementary theory of formal languages. Prerequisite: EECS 22; Math 162 recommended.

124. Introduction to Microprocessors
Overview of microprocessor organization. Hardware/Software tradeoffs. I/O subsystem implementation; Interrupt techniques; interfacing keyboards, displays and memories. Microprocessor software development. Survey of currently available microprocessors. Prerequisites: EECS 22 and 122.

126. Operating Systems
Introduction to operating system organization. Management of memory, processors and other system resources; deadlock problems and avoidance. Process interaction and communication. Sharing and protection of processes and data. File structures, implementation considerations. Prerequisite: EECS 15 and 22.

128. Logic Programming
Application of logic to problem-solving and programming; logic as a language for specifications, programs, databases and queries; separation of logic and control aspects of programs; bottom-up reasoning (forward from assumptions to conclusions) and top-down reasoning (backward from goals to subgoals) applied to the task of programmimg.

129. Special Topics in Computer Science
Courses on various subjects of current interest. May be taken more than once if topics differ.

131. Control Systems I
Detailed considerations of the mathematical theory of linear feedback control systems. Topics include: Transfer functions, relation between time and frequency domain characteristics; analysis and design, using root locus concepts and frequency response plots; performance criteria and sensitivity; stability. Laboratory. Prerequisites: Applied Mathematics 106, EECS 111.

132. Control Systems II
Continuation of 131. Controllability and observability. Stabilization by state variable feedback. Optimal linear regulator. Prerequisite: EECS 131.

141. Communications Systems
Signal description. Fourier transforms, filtering, noise description, linear modulation and demodulation, exponential modulation and demodulation, pulse modulation. Prerequisite: EECS 151.

151. Electronics I
Electron ballistics, emission theory, semiconductor theory. Extension of the study of electronic amplifiers to include wideband and radio frequency amplifiers, and the principles and applications of feedback. Laboratory. Prerequisites: E 102, EECS III.

152. Electronics II
Continuation of 151 to develop features of high-frequency power amplifiers, oscillators, modulation systems. Communications system. Introduction to nonlinear electronic circuits. Laboratory. Prerequisite: EECS 151.

153. Electronics III
Survey of integrated circuit processes; integrated components. Monolithic linear and digital integrated circuit analysis and design. Prerequisite: EECS 152.

161. Electromechanical Energy Conversion
Introduction to energy conversion equations and applications to tranducers, rotating amplifiers. Machine dynamics, transfer function realization, and modeling of physical electromechanical systems. Laboratory. Prerequisite: E 103.

162. Electric Power Systems
A study of systems which transmit electric energy from the point of generation to the point of use. Three phase systems. Faults. Reliability. Load flows. Prerequisite: E 103.

190. Undergraduate Research
Open to Departmental Scholars only.

198. Practicum
Open to Departmental Scholars only.

199. Directed Research
Investigation of an approved electrical engineering problem and preparation of suitable thesis covering the investigation. Meetings with faculty advisor as required. The student presents results of his/her thesis work at a Senior Thesis Conference normally held at the outset of the Spring term.

200. Electrical Engineering and Computer Science Graduate Seminars (1-2)
Regularly scheduled seminars on topics of current interest in the fields of electrical engineering and computer science (1 to 2 units). Consult Department office for detailed information.

201. Electromagnetic Field Theory I (2)
Time-varying electromagnetic field concepts starting with Maxwell's equations. Use of electric and magnetic vector potentials. Field theorems. Reflections and refraction of plane waves at interfaces. Rectangular wave guides and resonators. Boundary value problems in cartesian coordinates. Prerequisite: EECS 104.

202. Electromagnetic Field Theory II (2)
Cylindrical and spherical wave functions. Circular wave guides and resonators. Spherical cavities. Boundary value problems in cylindrical and spherical coordinates. Prerequisite: EECS 201.

203. Microwave Networks I (2)
General transmission line theory. Smith Chart and impedance matching techniques. Maximally flat and Chebyshev stepped and tapered impedance transformers. Scattering, transfer, impedance, and ABCD matrix representations of microwave networks. Microwave network theorems. Prerequisite: EECS 201.

204. Microwave Networks II (2)
Passive microwave component analysis and design with an emphasis on strip line techniques. Both narrow and broadband devices to include power dividers, couplers, hybrids, filters, and transformers. Design techniques of integrated microwave networks. Prerequisite: EECS 203.

205. Active Microwave Devices
Scattering parameters and noise parameters of microwave transistors; silicon bipolar transistors and gallium arsenide MESFET transistors; device physics, models, and high frequency limitations. Application to microwave amplifier and oscillator design.

206. Antennas I (2)
Introductory antennas. Fundamentals of radiation, patterns, directivity, gain, apertures and linear radiators. Theory of phased arrays. Systems aspect of antennas used in communications and radar. Prerequisite: EECS 201.

207. Antennas II (2)
Continuation of 206. Analysis and design of frequency independent antennas, reflector and aperture antennas to include radiating slots and horns. Introduction to the method of moments for analyzing linear radiators using numerical methods. Prerequisite: 206.

208. Introduction to Masers and Lasers (2)
An introduction to the principles of maser and laser operation based on classical concepts and electrical engineering analogies. Consideration of the maser and laser as practical electronic devices and their applications. Prerequisites: EECS 201 and Physics 155-156.

209. Topics in Electromagnetic Field Theory (2)

210. Introduction to Modern Network Analysis (2)
An introduction to modern network analysis techniques: fundamental laws, basic passive and active network elements, loop- and cutset- (node-) analysis matrix equations for linear RLCM networks, solution to first- and second-order networks in both time and frequency domains. This course may not be taken for credit by a student with an undergraduate degree in electrical engineering.

211. Modern Network Analysis (2)
A study of network theory from modern points of view. A unified presentation of the formulation of network equations using the matrix approach. Interrelationships of the loop equations, cutset equations, and state equations. Proofs and applications of network theorems. Prerequisite: EECS 111.

212. Modern Network Analysis II (2)
Continuation of 211. Frequency analysis of excitation and response; study of network responses using Laplace transform methods and superposition integral, two-port networks and their properties; device and parameters, interconnections of two-ports. N-ports and n-terminal networks. State variable techniques. Prerequisite: EECS 211.

213. Linear System Analysis (2)
Mathematical methods in the analysis and design of linear systems, network modeling of devices and systems, system simulation, system response via transfer functions and state variables, stability problems, discrete time systems, controllability, observability, and optimization. Prerequisite: EECS 211.

214. Topological Study of Linear Networks (2)
Topological analysis of passive and active linear networks; planarity and duality, passive one-ports and two-ports, flowgraph techniques, analysis of active linear networks, applications to switching networks. Introduction to topological synthesis and outher applications. Prerequisite: EECS 211.

215. Network Synthesis I (2)
Input immittance properties. Positive real functions. Synthesis of two-element kind and RLC one-ports. Synthesis of transfer functions. Properties of second-order systems. Introduction to the ideal operational amplifier. Second-order low-pass networks. Prerequisites: EECS 211 and 212.

216. Network Synthesis II (2)
Continuation of 215. Second-order band-pass and high-pass networks. Magnitude and phase functions. Approximations. Low-pass, band-pass, and high-pass passive and active realizations. Prerequisite: EECS 215.

217. Operational Amplifier Networks (2)
Ideal operational amplifier. Analysis of operational amplifier networks. Linear and non-linear operational amplifier applications. Design of active RC circuits. Practical limitations of the operational amplifier. Prerequisites: EECS 211 and 212.

218. Computer-Aided Circuit Analysis and Optimization (2)
A survey of modern computer techniques for the analysis of linear and non-linear general networks. Numerical and symbolic methods, tolerance analysis, and optimization. Prerequisites: EECS 212, 213, or 214 and computer programming knowledge.

219. Computer-Aided Integrated Circuit Design (2)
Device modeling with emphasis on features and constraints of integrated circuit design. Computer assisted designs including Schottky clamped TTL and n-channel MOS circuits. Prerequisites: EECS 210 and 265 or familiarity with bipolar of MOS transistors.

220. Operational Amplifier Applications (2)
Mathematics of basic operational-amplifier circuits. Applications in nonlinear circuits. Broadbanding. Data acquisition systems. Sample and hold circuits. Single-and multiple-amplifier active filters. Modeling. Prerequisites: CS 217 and 131.

229. Topics in Network Theory (2)

230. Introduction to Control Systems (2)
An introductory presentation of state space theory of linear systems. Modern description by matrices and vectors. Relationship of the modern state space representation to classical transfer function description of dynamic systems. State-variable feedback. Stability (Routh-Hurwitz, Nyquist). Design (Bode diagrams, Root-Locus). This course may not be taken for credit by a student with an undergraduate degree in electrical engineering. Prerequisite: AM 106 and AM 145.

231. Design of Feedback Control Systems (2)
Design of linear, continuous control systems utilizing techniques of the frequency response method, root-locus, and parameter plane method. Time and frequency response correlation and steady-state analysis. Prerequisite: EECS 131.

232. Introduction to Nonlinear System (2)
Graphical analysis of nonlinear systems —phase plane. Basic nonlinear phenomena. Linearization. Limit cycles and frequency analysis by the describing function method. Stability in the sense of Liapunov. Absolute stability and Popov's method. Prerequisite: EECS 2300 or equivalent.

233. Introduction to Discrete Systems (2)
Description of discrete signals and sampler operation. Linear system analysis by Z-transform and state space techniques. Digital filtering. Prerequisite: AM 106 or equivalent.

234. Discrete System Analysis and Design (2)
Continuation of 233. Design of digital filters and control systems. Quantization effects. Discrete Fourier Transform. Nonlinear Systems. Stability. Prerequisite: EECS 233.

235. Estimation and Identification (2)
Gaussian random variables. Maximum likelihood and Bayesian estimation. Least squares estimation. Optional linear filter (Kalman filter). System identification. Prerequisites: EECS 236 and AM 111.

236. Introduction to State Space Analysis (2)
Concept of state vector equations. Complete solution of linear vector equations. Controllability and observability. Stability and sensitivity. Optimality. Prerequisites: EECS 131 and AM 146.

237. Introduction to Optimal Systems (2)
Variational calculus and optimal control. Euler-Lagrange equations. Pontryagin's maximum principle. Bellman's dynamic programming. Linear regulator problem. Time-optimal control. Prerequisite: EECS 236.

238. Optimization Techniques (2)
Numerical techniques for optimization. Mathematical programming: linear, quadratic, nonlinear. Iterative techniques: gradient, Newton, dynamic programming. Prerequisite: EECS 237.

239. Topics in System Theory (2)

241. Theory of Communication I (2)
A general introduction to communication theory. Fourier series and transforms. Linear systems. Amplitude and frequency modulation. Elementary concepts in probability theory. Prerequisite: EECS 151.

242. Theory of Communication II (2)
Continuation of 241. Random signals. Noise in modulation systems. Pulse modulation. Data transmission. Optimum receivers. Prerequisite: EECS 241.

243. Information Theory I (2)
An introduction to the fundamental concepts of information theory. Source coding. The discrete channel without memory. Prerequisites: 241 and AM 111.

244. Information Theory II (2)
Continuation of 243. Cyclic codes. Models for information sources. The discrete channel with memory. The continuous channel. Prerequisite: EECS 243.

245. Signal Detection Theory (2)
Signal detection in a noisy environment. Decision criteria. Hypothesis testing. Parameter estimation. Prerequisites: EECS 242 and AO 262.

246. Coherent Communication Theory (2)
The use of phase-locked loops in coherent communication systems. Modulation schemes. Uncoded and coded systems. Prerequisites: EECS 242 and Am 262.

247. Exponential Modulation (2)
Frequency and phase modulation. Spectra. Noise in FM. Pre-emphasis-de-emphasis. Threshold effects. Spikes. Threshold improvement using PLL and FMFB. Prerequisite: EECS 242.

248. Pulse Modulation (2)
The sampling principle. Pulse modulation techniques. Pulse code modulation. Differential PCM. Delta modulation. Correlative techniques. Channels. Prerequisite: EECS 242.

249. Topics in Communication Theory (2)

250. Electronics (2)
A basic survey course in electronics: discussion of electronic modes of operation—digital and analog; semiconductor theory; PN junction; bipolar transistors, field effect transistors, electronic switches and applications; analog devices and applications—elementary differential amplifiers, operational amplifiers, active filters. This course may not be taken for credit by a student with an undergraduate degree in electrical engineering. Prerequisite: EECS 210

251. Fundamentals of Transistors and Circuits (2)
Physics of semiconductors and semiconductor devices, equivalent circuits, simple amplifiers. Prerequisite: EECS 152.

252. Transistor Circuit Design (2)
Stability, biasing problems, low-frequency response, feedback, D.C. amplifiers, power amplifiers, and power supplies. Prerequisite: EECS 251.

253. High-Frequency Transistor Circuits (2)
High-frequency equivalent circuits, neutralization, tuned amplifiers (signal), tuned amplifiers (power), switching characteristics, noise problems. Prerequisite: EECS 252.

254. Electronic System Analysis and Design I (2)
Two-port methods of feedback amplifiers analysis. Models for return-ratio and forward gain calculations. Sensitivity analysis. Stability in frequency and time domains. Compensation for maximally flat gain magnitude. Prerequisite: EECS 253.

255. Electronic System Analysis and Design II (2)
Review of charge-storage and Ebers-Moll models for BJT'S. Development of other models for semiconductor devices. Introduction to process-oriented models. Prerequisite: EECS 251.

256. Electronic System Analysis and Design III (2)
Two-port scattering parameter models. Stability and alignability of tuned and wideband filter design in transformed frequency variables. Transit-time mode of oscillations. Class C bipolar amplifiers. Intermodulation distortion. Prerequisite: EECS 254.

257. Filter Theory I (2)
A development of the basic principles of low-pass passive filter networks. Considers maximally flat, Butterworth, and Chebychev responses. Develops synthesis procedures. Prerequisites: EECS 111 and AM 135.

258. Filter Theory II (2)
Extends the developments of Filter Theory I to include band pass filters, impedence transformers, coupled resonators, and time response. Prerequisite: EECS 257.

259. Topics in Electronic Circuits (2)

264. Semiconductor Device Theory I (2)
The physics of semiconductor materials, junctions and contacts is developed as a basis for understanding all types of semiconductor devices. Prerequisites: A course in modern physics and EECS 151.

265. Semiconductor Device Theory II (2)
A continuation of 264 including bipolar transistors. MOS and junction field-effect transistors, and semiconductor surface phenomena. Prerequisite: EECS 264.

266. Integrated Circuit Design I (2)
Survey of monolithic processes and integrated components. Integrated design techniques and examples of linear and digital circuits. The course focuses on major design ideas and the differences between discrete and integrated circuit design, rather than detailed circuit analysis. Prerequisites: EECS 252 and 264.

267. Integrated Circuit Design II (2)
Linear and digital integrated circuit analysis and design. L.S.I., M.S.I. memories. Computer-aided analysis. Prerequisite: EECS 266.

269. Topics in Semiconductors and Semiconductor Technology (2)

274. Silicon Processing I (2)
Basic material properties, crystal structure and defects, crystal growth, homo and hetero epitaxy, oxidation, diffusion and ion implantation, chemical and electrochemical processes, thin film (metal and dielectric) processes, photolithographic process and evaluation methods used in these processes. Prerequisite: EECS 264.

275. Silicon Processing II (2)
Continuation of 274. Silicon monolithic technologies. Fabrication methods of basic passive and active, bipolar and field effect circuit components and their characteristics. Methods and processes used for component isolation and fabrication of integrated circuits. Methods of process control and special topics related to reliability. Prerequisite: EECS 274.

276. Hybrid Processing (2)
Materials and processes for thin and thick film hybrid circuits and systems. Packaging materials and methods. Prerequisite: EECS 264.

279. Topics in Semiconductor Circuits (2)

280. Power Transmission System (2)
Calculation of transmission line parameters. Sequence impedances, bundled conductors, multiplex calculations. Introduction to EHV systems, AC and DC operation. Switching transients and voltage recovery.

281. Introduction to Power Systems (2)
Introduction to power network modeling. Development of symmetrical components and their use for fault analysis. Power transfer concepts and system protection.

282. Computer Analysis of Power Networks I (2)
Introduction to network topology. Matrix algebra. Incidence matrices. Development of Z-BUS, Y-BUS, Z-LOOP, etc., by singular and nonsingular transformations. Three phase analysis including symmetrical and Clark's components. Short circuit studies and relaying.

283. Computer Analysis of Power Networks II (2)
Numerical analysis, load flow studies, load representation, transformer modeling. Development of reduction techniques including triangularization and diakoptics. Network equivalents. Prerequisite: EECS 281.

284. Power System Control I (2)
Concepts of modern control theory applied to theory of eigenvalue sensitivity analysis; linear analysis of load—frequency control of power systems. Prerequisite: EECS 236.

285. Electromechanical Rotating Device Theory (2)
Introduction to mechanical and electrical dynamics of synchronous machines. Excitation system and modeling of d.c. machines. Induction motor transients. Application of power semiconductors to rotating machines.

286. Power System Stability (2)
Modeling of fossil-fuel, nuclear and water wheel power plants. Excitation systems and controls. Two machine stability, equal area criterion and swing equations. Large system dynamics, mechanical and electrical transients. Prerequisite: EECS 285.

287. Distribution System Planning (2)
Planning techniques as applied to electrical utility distribution planning. Analytical techniques and computer applications. Load forecasting, economic sizing of substations, economics conductor sizing. Voltage control by reactor and capacitor methods. Optimum placement of capacitor on radial feeders. Power factor correction. Transformer management. Load energy management control using microprocessor applications.

288. Power Systems Seminars (2)

289. Topics in Power Systems (2)

299. Electrical Engineering Problems and Thesis Research (2-4)
Special Electrical Engineering problems. By arrangement.

301. Introduction to Programming (2)
Elements of computer systems; algorithmic solution of problems; programming in block structured, ALGOL-like programming languages; procedures; local and global variables; call by name, call by value; introduction to top-down and bottom-up structured programming. Programs will be written and run on the computer. (Units for this course may not be applied toward the requirements of any graduate degree in the EECS department, or Engineering Management).

302. Introduction to Digital Systems (2)
Information representations in digital systems: BCD codes, gray codes, codes for non-numeric processing; number systems: binary, octal, hexadecimal; fixed and floating-point numbers; arithmetic in two's complement, one's complement, and decimal signed number systems. Boolean algebra, switching functions, truth tables and identities. Analysis of combinational and sequential logic circuits; functional types of gates and flip-flops, minimization of switching functions. (Units for this course may not be applied toward the requirements of any graduate degree in the EECS department, or Engineering Management).

305. Theory and Practice of Combinational Logic (2)
Canonical expressions for switching functions. Design of combinational logic circuits. Techniques for the minimization of switching functions. Special considerations for miltiple-output circuits. Bridging from exclusive or and majority gates. Dot AND/OR'ing with open collection devices; tri-state buses. Fan-in, fan-out. Impact of MSI and LSI; implementation alternatives

using data selectors, ROM's, and PLA's. Design of and with adders, carry-look-ahead, decoders, encoders, multiplexers, data selectors, etc. Worst-case propagation delays and noise immunity. Prerequisite: EECS 302. (Units for this course may not be applied toward the requirements of any graduate degree in the EECS department.)

306. Theory and Practice of Sequential Logic (2)

Sequential switching network analysis and synthesis. Mealy and Moore models of sequential machines. State assignment and state equivalence. Flip-flop functional types and derivation of excitation functions; latches, master-slave, and edge-triggered implementations; direct setting and resetting of flip-flops; set-up and release times; minimum clock pulse widths, maximum clock rate and skew. Race conditions; analysis and control of static, dynamic and essential hazards. Design of shift registers, counters, scalers, and serial arithmetic units. Prerequisite: EECS 305.

307. Digital Computer Organization and Implementation (2)

Overview of major subsystems of small to medium-scale digital computers. Machine instruction set characteristics. Typical arithmetic and logic unit functions, register data flow organization, bussing schemes, and their implementations. Computer memory systems; addressing techniques. Methods of system timing and control; hardware sequencers, microprogramming. Register Transfer language and microoperations. I/O subsystem structure; interrupts; direct memory access and I/O bus interfacing techniques. This course will include a detailed computer design project. Prerequisites: EECS 306 and 311.

308. Digital Computer Architecture and Structure (2)

Survey, comparison, and contrasting of the architectures and structures of existing and proposed digital computers. Multiprocessing; multiprogramming, paging and segmentation schemes; level-structured virtual machine concepts. Cache memory systems. Impact of architecture/structure on software; architectures/structures for special-purpose systems. Other topics of interest. Prerequisite: EECS 307.

309. Digital Laboratory (1)

A practical laboratory experience in digital logic design. Documentation standards, debugging techniques, and an introduction to modern digital test equipment. Prerequisite: EECS 305 and 306 (or concurrent enrollment in 306).

310. Machine Independent Programming (2)

Machine independent programming techniques. Introduction to the theory of algorithms. Data structures: stacks, queues, deques, trees, linked lists. Internal sorting: insertion, exchange, selection; external sorting. Searching techniques; sequential, binary, hashing. Programs will be written and run on the computer. Prerequisite: EECS 301 or 410 or extensive programming experience in a LISP-like or ALGOL-like language.

311. Machine Dependent Programming (2)

Machine dependent programming techniques. Computer architecture for the programmer. Machine and assembler language programming; implementation of data structures, program linkage, interfacing ALGOL and assembly language programs and subroutines, recursion and reentrancy, input-output routines. Impact of machine architecture on software. Assemblers and interpreters. High-level languages for machine dependent programming. Programs will be written and run on the computer. Prerequisites: EECS 302 and 310. (Units for this course may not be applied toward the requirements of an MSCS degree.)

312. Theory and Design of Programming Languages (2)

Programming language design and programming language processors. Formal description and analysis of programming languages: BNF, meta-languages. Features of various programming languages, areas of applicability, problems of implementation. Introduction to translator methodology; language types and run-time environments required for each. Programs will be written and run on the computer. Prerequisite: EECS 310 and 311.

313. Theory and Design of Operating Systems (2)

Introduction to operating system theory. Management of memory, processors, and other system resources; deadlock problems and avoidance. Process interaction and communication. Process and data sharing and protection. Operating system implementation; real-time and interactive, single batch, multi-programming, and multiprocessing systems. Brief survey of currently used operating systems. Programs will be written and run on the computer. Prerequisite: EECS 310 and 311.

314. Digital Computer Arithmetic (2)

A comprehensive study of advanced techniques for use in digital systems requiring performance of arithmetic operations with emphasis on ultra-highspeed "number-crunchers." Prerequisites: 308 and 311.

316. Advanced Switching and Automatic Theory (2)
Special classes of switching functions. Functional decomposition. Transition systems. Regular expressions and regular machines. Other related topics of interest. Prerequisites: EECS 306 and AM 140 or consent of instructor.

317. LSI Memory (2)
Storage characteristics of the most common bipolar and MOS memory circuits. Relative advantages and disadvantages of bipolar and MOS memory circuits. Organization of LSI memory components. Characteristics of presently available RAM, ROM, CAM and shift register LSI memory components. The LSI memory market and economic factors. Prerequisites: EECS 251 and 306.

319. Microprogramming (2)
Historical review of computer development and microprogramming. General methods for control of digital systems; basic principles of the microprogramming approach. Applications of microprogramming. Memory technology. Design aids to microprogramming. Study and evaluation of a microprogrammed computer. Current trends in microprogramming research. Prerequisites: EECS 307 and 311 or consent of instructor.

321. Computer Communication (2)
A comprehensive study of teleprocessing systems. Prerequisites: EECS 342, 307, and 311.

322. Computer Graphics (2)
A comprehensive study of both hardware and software aspects of graphic input/output systems for digital computers. Prerequisites: EECS 307 and 311 or consent of the instructor.

323. Design of Reliable Digital Systems (2)
Hardware and Software techniques for meeting stringent reliability demands with digital equipment. Digital system failure modes and their models for combinational and sequential circuits. Fault detection and diagnosis. Hardware redundancy techniques. Error-detecting and error-correcting codes. Other related topics of interest. Prerequisites: EECS 307 or consent of the instructor.

324. Parallel Computation Systems (2)
Organization and architecture of systems in which multiple processors are applied to the execution of a single task. Overview of the general design of existing parallel computers. Problems of programming parallel computers effectively with emphasis on methods for efficient parallel execution of sequential algorithims and on the implications of the methods for computer design. Prerequisites: EECS 308 or consent of instructor.

326. Data Base Systems and File Management Theory and Techniques (2)
Theory and organization of large-scale file and data base systems. Survey of techniques for their use and management. Prerequisite: EECS 313.

327. Advanced Systems Architecture (2)
This course will vary somewhat from year to year and will include detailed studies of the architecture of state-of-the-art computer systems. Emphasis will be on large, high-performance machines. Prerequisites: EECS 308, 313 or consent of instructor.

328. Introduction to Artificial Intelligence (2)
Artificial intelligence viewed as knowledge engineering. Historical perspective. Problems of representation: A.I. as a problem in language definition and implementation. Topics include: LISP, formal reasoning, natural language, vision and robotics, research techniques. Prerequisite: EECS 312. EECS 420 Recommended.

329. Special Topics in Computer Science (2)
Courses on various subjects of current interest. May be taken more than once if topics differ.

330. Statistical System Analysis (2)
Analysis and design of control systems subject to stochastic input signals. Wiener-Kalman's prediction theory. Design of optimal control. Prerequisite: EECS 236.

341. Survey of Communication Systems (2)
A general survey of the theory and applications of modern telecommunication systems. Emphasis on digital communication, and particularly computer communications. Signal description. Fourier analysis. Channels. Transmission systems. Land lines. Radio systems. Modulation. (Not to be taken by students majoring in Communications Theory.)

342. Data Communication Systems (2)
The regulatory climate. Channels and transmission facilities. Data communication system components: modems, concentrators, multiplexers, port selectors, binary serial interfaces. Data link controls. Network architectures. Packet switching. Prerequisite: EECS 151.

343. Survey of Satellite Communication Systems (2)
A general survey of the operation of communication satellites, and related satellite systems. Orbital mechanics and trigonometry. Power sources. Antennas. Power budgets. System components. Multiple access. Economics.

344. Regulation and Economics of the Communication Industry (2)
Economics of communication. The history and growth of regulation. Domestic and international policy. Competitive influences. Private and Public systems. Regulating agencies.

345. Phase-Locked Loops I (2)
The basic loop. Components. Describing equations. Stability. Transients. Modulation and demodulation. Prerequisite: EECS 242.

346. Phase-Locked Loops II (2)
Additive noise response. Random modulation. Nonlinear operation with noise. Cycle-slipping. Prerequisites: EECS 345.

347. Digital Communication System (2)
Transmission of digital signals over real channels. Baseband systems. Equalization. Modulation. Synchronization. Error detection and correction. Prerequisites: EECS 242 and AM 111.

348. Communication System Components (2)
A survey of some of the most important components used in modern communication systems. Oscillators. Modulators. Demodulators. Modems. Data processors. Prerequisite: EECS 242.

349. Communication System Design (2)
Elements of communication systems. Decibels. Noise. Transmission channels. Modulation forms. System structure. Prerequisite: EECS 242.

351. Switching Devices (2)
Suitable equivalent circuits. Semiconductor switching characteristics; delay, storage time, recovery time, charge control parameters. Circuit techniques; circuit theorems; solution of differential equations with boundary values by inspection. Elementary switching applications. Prerequisite: EECS 251.

352. Timing and Pulse Generation (2)
Regenerative switching and wave-form generation, effects of inductance in switching and pulse circuits, pulse-forming circuits and high-power pulse amplifiers. Prerequisite: EECS 351.

360. Introduction to Magnetic Engineering (2)
The properties and characteristics of magnetic materials are applied to five particles, recording media, ferro and ferri-magnetic devices. Examples include magnetic recording heads, memory cores, and tape cores. Prerequisite: EECS 104.

361. Magnetic Recording of Signals (2)
The technology of magnetic recording is explored. The magnetic field around a recording head, tape magnetization, media characteristics and various recording methods are studied. Prerequisite: EECS 360.

362. Magnetic Reproduction of Signals (2)
The continuation of 361. The description of a magnetic record as seen by the reproduce head. Influences of spacing, media thickness and noise are considered. Prerequisite: EECS 361.

369. Special Topics in Magnetics (2)

371. MOS Integrated Circuit Design I (2)
Theory and design of MOS/LSI integrated circuit. Prerequisite: 264.

372. MOS Integrated Circuit Design II (2)
Continuation of 371. Prerequisite: 371.

373. Optical Electronics I (2)
Theory of semiconductor heterojunction devices. Light-emitting diodes, semiconductor lasers and integrated optics. Prerequisite: 264.

374. Optical Electronics II (2)
Continuation of 373. Prerequisite: 373.

376. Hybrid Circuit Design (2)
Design of thin and thick film hybrid systems. Hybrid components.

377. Microwave Integrated Circuits (2)
Analysis and design of microwave integrated components. Microwave circuit analysis and testing. Prerequisite: 264.

379. Topics in Microelectronics (2)

381. Analog MOS Circuit Design I (2)
MOS physics and fabrication. Design of analog MOS building blocks including: enhancement load inverters. CMOS stages, cascode, differential stages. Frequency response of MOS building blocks. Design of MOS operational amplifiers. Prerequisites: EECS 264, 266.

382. Analog MOS Circuit Design II
Continuation of 381. Low frequency distortion in MOS circuits. Application of MOS op-amps to A/D-D/A converters, codecs, and switch capacitor filters. Prerequisites: EECS 381.

401. Compiler Implementation (2)
Practical techniques and problems associated with writing a compiler for a high-level programming language; scanning, parsing, sematic routines; code generation; run-time resource allocation. The course will include a detailed compiler writing project. Prerequisite: EECS 312.

402. Software Engineering (2)
Systematic approaches to: Program design, project management, implementation, documentation, and maintenance. Hierarchical

design methodology, use of Parnas modules, design correctness proofs. Structured programs, to-down implementation schemes, use of structured program flow control, stepwise refinement, monitors and debugging techniques. A project will be required, involving the cooperation of several individuals in the design and implementation of a large program. Prerequisites: EECS 310 and 311.

403. Current Papers in Computer Science (2)

Study and critique of recent papers in the literature. Papers on computer hardware will be taken from technical journals such as IEEE Transactions on Computers, ACM's SIGMINI, SIGMICRO, and SIGARCH, and certain conference proceedings, such as the Annual Symposium on Computer Architecture. Software papers will be taken from publications such as the Communications of the ACM, the ACM Journal, IEEE Transactions on Software Engineering, BIT, ACM SIGPLAN Notices, and conferences such as the International Conference on Software Engineering. Papers on theory of computation will be taken from the following sources: technical journals, such as Acta Informatica, Communications of the ACM, Journal of the ACM; conferences, such as POPL, STOC, ICALP, IJCAI, AISB; and unpublished technical reports on current research in hardware, software, and theory. Prerequisites: EECS 308 (hardware), EECS 313 (software), EECS 421 (theory).

410. Introduction to PL/M (2)

Brief overview of microcomputer organization. Algorithmic solution of problems. Programming in PL/M: procedures and blocks; local and global variables; parameters; program structure. Considerations peculiar to microprocessors. (This course may not be applied toward the requirements of any graduate degree in the EECS department.)

411. Microprocessor Chips and Support Logic (2)

Historical background of microprocessors; survey of currently available microprocessor systems and applications. Prospective of microprocessors relative to computers. Overview of microprocessor organization. Control techniques. Arithmetic and logic unit design. Prerequisite: EECS 307 or ME 208.

412. Case Studies in Microprocessor Applications (2)

Microprocessor firmware and software development. I/0 subsystem implementation; interrupt techniques, keyboards, displays, and memories. Discussion of uses and future trends. Prerequisite: EECS 311 and 411.

413. Advanced Microprocessor Architecture (2)

Special purpose, unusual and advanced MOS and bi-polar microprocessors. Prerequisite: EECS 411.

414. Input-Output Devices (2)

Card readers, line printers, disks, drums, magnetic tapes, paper tape readers, paper tape punch, keyboards, CRT's; analog-to-digital and digital-to-analog converters. Prerequisite: EECS 307.

415. Input-Output Structures (2)

Data transfers: synchronous and asynchronous; device selection and control; interfacing. Interrupt architectures; direct memory access. Channels, I/0 processors. Prerequisite: EECS 414.

416. Formal Language (2)

An introduction to the basic mathematical theory underlying programming languages. Regular sets, context-free languages, deterministic context-free languages. Theory of grammars and parsing algorithms. Relevant automata theory with emphasis on applications to language translation.

417. Memory Hierarchies (2)

Random, sequential, direct, and associative access. Operational characteristics of TTL, MOS, core, CCD, and Magnetic bubble memories. Interleaving, paging, segmentation; cache and virtual memory systems. Prerequisite: EECS 307.

418. Performance Evaluation (2)

Measurement, simulation, and analytic determination of computer systems performance. Work load characterization. Bottleneck analysis, tuning. Prerequisite: EECS 308.

420. Functional Programming/Principles of Programming Languages (2)

Programming in a modern, high-level, functional programming language, i.e. one with functions (or procedures) as first-class objects, and preferably with facilities for abstract data types. Programming language concepts: applicative languages, strongly typed languages, modularization, data abstraction, control structures, data structures.

421. Computational Logic (2)

Introduction to the concepts of Truth, Deduction, and Computation in the formalisms of Propositional and Predicate Logic. Topics to be covered include: meta-theoretic notions of soundness, completeness, consistency, and decidability; primitive recursion and proof by induction; logic as a programming language. Prerequisite: exposure to Propositional Logic.

422. Denotational Semantics I (2)
Complete partially ordered sets, approximations and limits, least fixed points and continuous functions, and the -calculus provide the mathematical background. We can then discuss techniques for describing languages: semantic functions, environments, continuations, stores. Prerequisites: EECS 420, AM 140, 141.

423. Denotational Semantics II (2)
Continuation of 422.

424. Introduction to Computability (2)
The intuitive notions of computability, effective enumerability, and decidability; Turing machines, partial and total recursive functions, Church's thesis; primitive recursive functions, Ackerman's function, the u-operator; Gödel numbering, universal machines, the Halting Problem, the Word Problem. Prerequisite: EECS 421.

425. Analysis of Algorithms (2)
Measures of complexity, complexity of problems and algorithms, design of efficient algorithms; best, average, and worst case analysis; space and time hierarchies; NP-completeness; reducibility between problems; intractible problems. Prerequisites: EECS 424 and AM 180 or AM 110.

426. Program Proving/Verification, Synthesis, Transformation
Axiomatic semantics of programs; weakest preconditions; proving assertions about programs. Formalisms of Burstall, Dijkstra, Floyd, Hoare, Manna, McCarthy, and Scott. Partial correctness, termination, structural induction. Program transformation and synthesis. Prerequisite: EECS 421.

441. Communication Satellite Systems Engineering I (2)
Satellite system engineering considerations. Multiple access problems. System non-lineorities. Earth station characteristics. Modulation schemes. Prerequisites: EECS 242 or equivalent.

442. Communication Satellite Systems Engineering II (2)
Series of special topic lectures on particular engineering problems in satellite communication, primarily by experts working in the field. Prerequisite: EECS 441 or equivalent.

MECHANICAL ENGINEERING

Michel A. Saad, Ph.D., *Chair*
Professors: Richard K. Pefley, Michel A. Saad
Associate Professors: Eugene J. Fisher, R. Ian Murray

Mechanical Engineering provides the necessary background to design mechanical systems that are effective, efficient, economical and safe. In the Mechanical Engineering Department emphasis is placed on two phases of mechanical engineering: (1) design of machines and systems for their control; (2) design and analysis of thermofluid systems for the effective utilization of energy. Educational efforts are channeled to impart to prospective engineers not only a fundamental competence but also a versatile perceptive capability in analysis of engineering systems.

11. Design and Machine Tool Processes

Influence of material selection and manufacturing processes on engineering design.

15. Material Science

Physical basis of the electrical, mechanical, and thermal behavior of solids. Relations between structural and physical properties. Theory of dislocations, vacancies, and other defects and their effect on physical properties. Illustrations of the relationship between material selection, manufacturing processes and design. Laboratory. Prerequisite: Physics 6.

110. Machine Design I

Analytical and graphical analysis of linkages utilizing statics, dynamics, and strength of materials. Machine elements studied include electromechanical and pneumatic-hydraulic components. Prerequisites: 11, Engineering 43.

111. Machine Design II

Continuation of Machine Design I. System analysis and synthesis will be studied, including control systems. Solutions to design problems will be critically evaluated by employing case studies. Prerequisite: 110.

112. Advanced Machine Design

Continuation of Machine Design II—Emphasis is placed on design projects. Integration of various components into a complete machine is studied. Prerequisite: 111.

115. Design of Thermal Systems

Characteristics of power plant components, mathematical modeling and system simulation. Optimization, search methods, programming and economics.

125. Thermodynamics

Thermodynamic potentials and availability concepts. Nonreactive mixtures. Reactive mixtures with emphasis on the thermodynamics of combustion and chemical equilibrium. Prerequisite: Engineering 121.

135. Heat Transfer

Introduction to the concepts of conduction, convection, and radiation heat transfer, and application of these concepts to engineering problems. Prerequisite: Engineering 121.

136. Transportation Systems

Evaluation of various modes of transportation systems, including methods of propulsion. Economic and feasibility studies.

138. Nuclear Reactors

Introduction to principles underlying nuclear power reactor design. Senior standing required.

140. Advanced Dynamics

Derivation and solution of equations of motion of linear dynamic systems. Stability, introduction to feedback control systems, vibration and noise. Prerequisite: Engineering 42.

142. Fluid Mechanics

Introduction to gas dynamics. Concepts of lift and drag. Mechanics of laminar and turbulent flow. Introduction to boundary-layer theory. Application to selected topics in lubrication theory, aerodynamics, turbomachinery, and pipe networks. Prerequisite: Engineering 120 and 121.

150. Optimization of Engineering Systems I (2)

Methods of evaluation and optimizing complex Engineering Projects, optimization techniques, criteria for project evaluation; decision making under uncertainly; use of the computer in modeling and simulation.

151. Optimization of Engineering Systems II (2)
A continuation of ME 150.

160. Mechanical Engineering Laboratory
Introduction to design of experiments, instrumentation, data acquisition, error analysis, and report writing. Prerequisite: Senior standing.

205. Machine Vibrations (2)
Behavior of one, two, and multi-degree of freedom systems when exposed to periodic forcing functions.

207. Microelectronic Device Utilization in Mechanical Controls (2)
Types, performance characteristics, applications.

208. Microprocessor Utilization in Mechanical Controls (3)
Logic, machine control capability and limitation.

210. Nonlinear Oscillations I (2)
Phase plane and phase trajectories. Conservative systems. Discontinuous systems. State space. Stability. Prerequisite: 140.

211. Nonlinear Oscillations II (2)
Lyapunov's direct method. Applications, including rigid body motion. Computation of stability domains. Time-varying systems. Limit cycles and topological methods. Perturbation techniques. Prerequisite: 210.

215. Dynamics of Physical System I (2)
Vector kinematics and dynamics of particles and systems of particles. Energy and momentum. Systems of variable mass.

216. Dynamics of Physical Systems II (2)
Vector kinematics and dynamics of rigid bodies. Lagrange's equations. Prerequisite: 215.

225. Gas Dynamics I (2)
Flow of compressible fluids including one-dimensional isentropic flow, normal shock waves, frictional flow. Prerequisite: Engineering 121.

226. Gas Dynamics II (2)
Continuation of 225. Flow with heat interaction and generalized one-dimensional flow. Oblique shock waves and two-dimensional potential flow. Prerequisite: 225.

227. Gas Dynamics III (2)
Continuation of 226. Emphasis on linearized flow and the method of characteristics for supersonic flow. Methods of experimental measurements. Prerequisite: 226.

228. Gas Dynamics IV (2)
Flow of gases analyzed from a microscopic viewpoint. Prerequisites: 225 and 230.

229. Equilibrium Thermodynamics (2)
Extremum principles of thermodynamic equilibrium. Equations of state, thermodynamic potentials, phase transitions and thermodynamic stability. Theory of chemical equilibrium. Extensions and application to elastic systems and systems in the presence of fields. Prerequisite: 125 or equivalent.

230. Statistical Thermodynamics (2)
Kinetic theory of gases. Maxwell-Boltzmann distributions, thermodynamic properties in terms of partition functions, quantum statistics and applications. Prerequisites: Differential Equations and 121.

234. Combustion Technology I (2)
Theory of combustion processes. Reaction kinetics, flame propagation theories. Emphasis on factors influencing pollution. Prerequisites: Differential Equations and Engineering 121.

235. Combustion Technology II (2)
Continuation of 234.

236. Conductive Heat Transfer I (2)
Flow of heat through solid and porous media for steady and transient conditions. Consideration of stationary and moving heat sources. Prerequisites: Differential Equations and 135.

237. Conductive Heat Transfer II (2)
Continuation of 236.

238. Convective Heat and Mass Transfer (2)
Advanced problems in heat and mass transfer, with emphasis on convective heat and mass transport. Prerequisite: 135.

239. Two Phase Flow and Heat Transfer (2)
Considerations of possible flow regimes for closed conduits in terms of pressure drop, void fraction, and heat flux. Prerequisites: 272, 135, or equivalents.

240. Radiation Heat Transfer I (2)
Introduction to concepts of quantum mechanics, black body behavior and radiant heat exchange between real bodies. Two-hour lecture. Prerequisite: 135.

241. Radiation Heat Transfer II (2)
Continuation of 240.

242. Modern Developments in Heat Transfer (2)
Various topics in heat transfer. Heat pipe design, thermal contact conductance, modern insulation systems, thermal scale modeling.

243. Cryogenics (2)
Thermodynamic, heat transfer and fluid mechanic aspects of cryogenic systems.

244. Solar Energy for Heating and Cooling and Thermal Processes I (2)
Introduction to the use of solar energy for heating and air conditioning. Availability of solar energy. Solar collector and storage system design. Economics of design.

245. Design of Thermal Systems (2)
Mathematical modeling and system simulation of power generation systems. Optimization, search methods, programming and economics.

247. Solar Energy for Heating and Cooling II (2)
Continuation of 244.

250. Nuclear Engineering I (2)
Reactor types and applications for power production, breeding and special power sources. Fission processes, radioactivity and nuclear cross section applications.

251. Nuclear Engineering II (2)
Maxmellian Boltzmann neutron distributions in thermal reactors, diffusion theory boundary value problems, slowing down and neutron interactions in reactors which determine fuel loading and reactivity. Prerequisite: 250.

252. Nuclear Engineering III (2)
Special problems occurring in the energy removal and structural design of reactors, radiation protection and reactor shielding. Fuel cycles, fuel reprocessing and economic evaluations. Prerequisite: 251.

253. Reactor Theory I (2)
Neutron interaction with matter, theory of nuclear fission and chain reacting systems, diffusion theory applications for boundary value problems applied to thermal and fast reactors. Prerequisite: 252.

254. Reactor Theory II (2)
Neutron slowing theory, idealized and practical for absorption-fissioning media. Significance of low-energy neutron distributions. Prerequisite: 253.

266. Fundamentals of Fluid Mechanics (2)
Basic conservation laws and theorems of incompressible flows. Prerequisite: Engineering 120.

267. Ideal Fluid Flow (2)
Two and three dimensional flows of an incompressible, inviscid fluid. Prerequisite: 266.

268. Flow Past Hydro and Aero Shapes (2)
Flow past thin airfoils using distribution of sources and vortices. Generation of lift. Flow past finite wings. Flow past slender bodies of revolution.

269. Water Waves (2)
Mechanics of fluid motion and the effects on surface and submerged vehicles.

270. Physical Properties From the Molecular Viewpoint (2)
Microscopic theories of deformation and fracture. Electrical, thermal, and magnetic properties of materials. Prerequisite: 15 or equivalent.

271. Designing With Plastic Materials (2)
This course emphasizes the engineering properties of plastic. Properties of plastic materials and their use in the design of plastic parts.

272. Viscous Flow I (2)
Exact and approximate solutions for incompressible, viscous flow. Includes an introduction to boundary layer theory. Prerequisite: 266.

273. Viscous Flow II (2)
Continuation of 272. Transition and turbulence.

274. Processing Plastic Materials (2)
Processes used to make plastic parts and their influence on design.

275. Transient Hydraulic Analysis (2)
Applications of fluid mechanics principles to transient flow in piping systems. Analysis of systems containing turbo machinery. Prerequisite: Engineering 120.

277. Dimensional Analysis (2)
Determination of governing parameters for experimental studies and model tests: Buckingham's Pi Theorem, normalization of governing equations and boundary conditions. Order of magnitude estimates and justification for simplified differential equations.

280. Magnetohydrodynamics and Plasma Physics I (2)
Introduction to the physical principles and underlying properties of electrically conducting media. Elements of electromagnetic theory and the dynamics of charged particles. Thermodynamics and kinetic theory of ionized gases. Debye shielding, plasma oscillations, ionization and atomic processes, collisions, and relaxation times. Prerequisite: familiarity with electricity and magnetism.

281. Design: Applications of Fracture Mechanics and Fatigue Analysis I (2)
Material and environmental factors governing fatigue life of structural elements and related fracture mechanics.

282. Design: Applications of Fracture Mechanics and Fatigue Analysis II (2)
A continuation of 281.

283. Design: Friction, Wear, and Lubrication (2)
Analysis of liquid and gas film journal and thrust bearings, foil and hydro-lb, 36⅓ static bearings, theory of friction, frictional behavior of materials, wear.

286. Hydrodynamic Lubrication (2)
Reynolds equation, incompressible slider and journal bearings, elastohydrodynamic lubrication, disk and gear lubrication, numerical methods, foil bearings, introduction to gas bearings.

288. Energy Conversion I (2)
Introduction to promising methods of power generation using solar energy, thermoelectric effect, and fuel cells. Includes description of the physical phenomena involved, analysis of device performance, and assessment of potential for future use.

289. Energy Conversion II (2)
Discussion of magnetohydrodynamic power generation, thermiomic converters, and thermonuclear fusion. 288 is not a prerequisite.

290. Air Pollution in Urban Communities (2)
Air pollution meteorology, statistics of pollutant concentrations, microscale highway and street canyon models and mesoscale airport and urban models.

291. Mechanics of Sound and Noise Pollution (2)
Mathematical models to disperse the propagation of sound in urban communities. Examination of models from the standpoint of accuracy, utility and applicability.

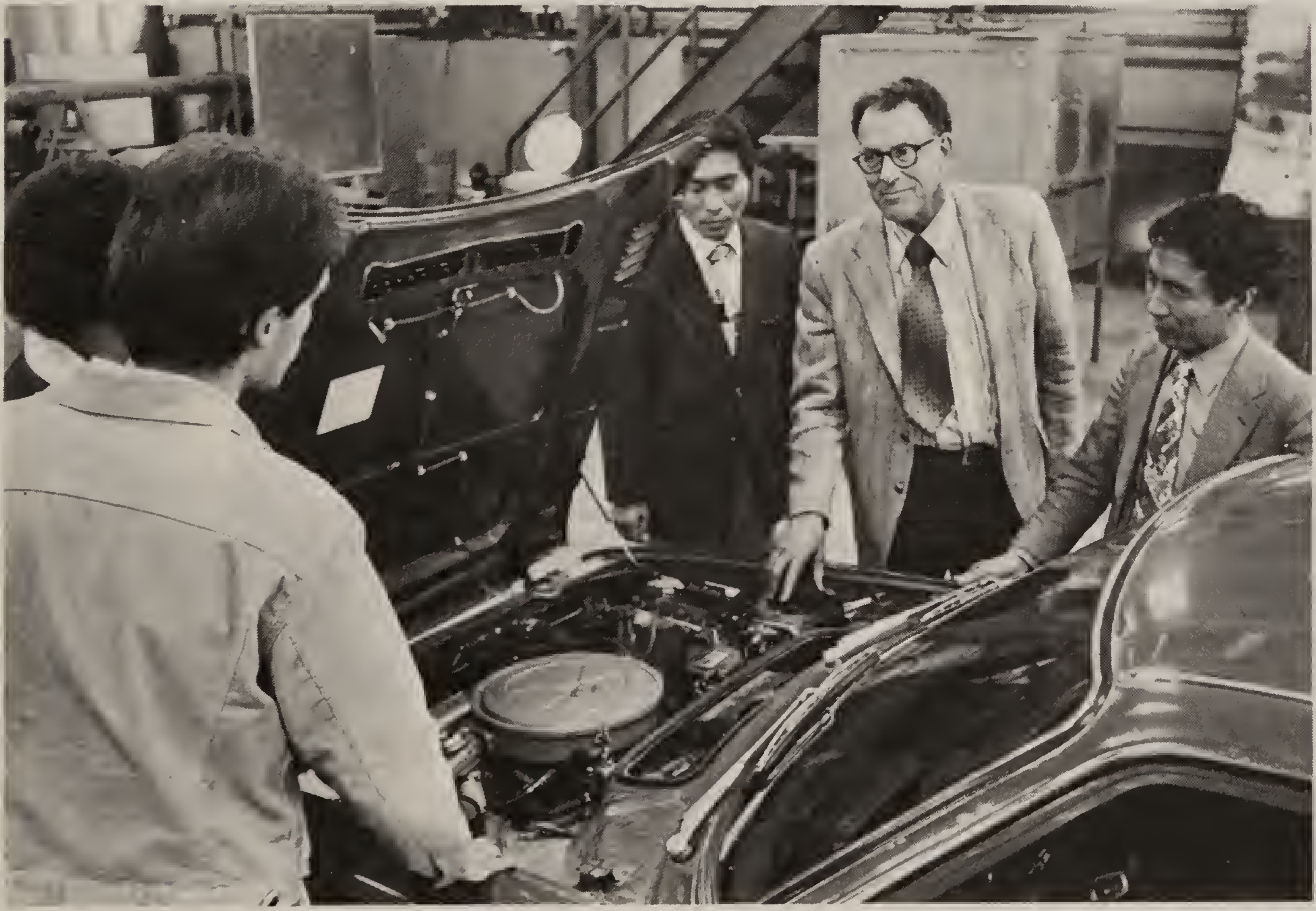
292. Project Management and Engineering Entrepreneurship (2)
Introduction to planning, organizing, managing, and controlling projects, programs, and technically oriented enterprises. Emphasis is upon the interactions between engineering and other management disciplines.

295. Science, Society and Survival (2)
An experimental course in which an experienced engineer in the design process will examine how engineers can use their creativity and initiative to direct technology so that it will remain the servant rather than become the master of mankind.

296. Business Orientation for Engineers (2)
Introduction to the business environment from the engineer's perspective.

297. Seminar (1 or 2)
A series of discrete lectures on current problems and progress in fields related to mechanical engineering.

299. Research M.S. Thesis/Special Problems (3 to 9 units)
By arrangement with the Department.



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